Performance Evaluation
of
CHART
-The Real-Time Incident Management System-
year 2000
(Draft Final Report)

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Performance Evaluation of CHART 2000
The Real-Time Incident Management System

Figure I: Area Road Network Map Covered by CHART
List of Terms and Abbreviations

0-9
10-46 – Incident code - Assistance to Driver
10-50 – Incident code - Minor Incident / Accident

A
AOC – Authority Operations Center
Arrival Time – Time, when the response unit arrived to the scene
ATM – Asynchronous Transport Mode
ATMS – Advanced Transportation Management System
AVCM – ATM Video Control Manager
AVL - Automated Vehicle Location

B
BWI – Baltimore/Washington International Airport

C
C2IOC – CHART 2 Interim Operational Capability
CCTV – Closed Circuit Television
CHART – Coordinated Highways Action Response Team
Cleared Time – Time, when the scene is cleared and normal traffic conditions are restored
COTS – Commercial off-the-shelf
CPOC – CHART Proof of Concept

D
DBM – Maryland Department of Budget and Management
DGS – Maryland Department of General Services

E
EOC – Emergency Operations Center
EORS – Emergency Operations Reporting System
ERU – Emergency Response Unit
ETP – Emergency Traffic Patrol

F
FITM – Freeway Incident Traffic Management
FMS – Field Management Station
FPU – Field Processing Unit

G
GIS – Geographic Information System
GUI – Graphical User Interface

H
HAR – Highway Advisory Radio

I
IEN – Information Exchange Network
IDT – Incident Duration Time
IOTC – Interim Operational Telecommunications Capability
ISP – Information Service Provider
ITS – Intelligent Transportation System

M
MDOT – Maryland Department of Transportation
MSHA – Maryland State Highway Administration
MdTA – Maryland Transportation Authority
MSP – Maryland State Police
NOVA – Northern Virginia Traffic Management System
NTSC – National Television Standards Committee

OOTS – Office of Traffic and Safety
PC – Personal Computer

RGB – Red, Green, Blue (computer graphics display)
Received Time – Time when the information on incident occurrence was received by the operator
Response Time – Time period between receiving information on incident and arrival of response unit on the scene

SNMP – Simple Network Management Protocol
SOC – Statewide Operations Center
SONNET – Synchronous Optical Network
SQL – Structured Query Language

TAR – Travelers Advisory Radio
TAT – Travelers Advisory Telephone
TOC – Traffic Operations Center

UMD – University of Maryland at College Park

VMS (DMS/CMS) – Variable Message Sign (Dynamic/Changeable Message Sign)

WWW – World Wide Web
Acknowledgements

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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 were involved in collecting and organizing the entire 2000 incident response data for this study.
EXECUTIVE SUMMARY

Objectives

This report presents the performance evaluation results of CHART in 2000, including both operations efficiency and the resulting benefits. This is part of the annual CHART performance review conducted by the Civil Engineering Department of The University of Maryland at College Park and MSHA staff for Maryland State Highway Administration (MSHA).

The purpose of this study is to assess the effectiveness of the Maryland CHART program with an emphasis on its ability to detect and manage incidents on major freeways and highways. The efficiency of the entire incident management operations along with its resulting benefits also constitutes the core of the study.

The evaluation study consisted of two phases. Whereas the focus of Phase-1 was on defining the objectives, identifying the available data, and developing the methodology, the core of Phase-2 was to reliably assess the efficiency of the incident management program and to estimate its resulting benefits from data available in the 2000 CHART incident operations record. As some information essential for efficiency and benefit assessment was not collected in 2000, this study presents only those evaluation results that can be directly computed from incident management data or derived with reliable statistical methods.

Available Data for Analysis

In 1996, an evaluation study with respect to the incident response system of CHART was conducted by COMSIS (COMSIS, 1996). In performing the evaluation, the 1994 incident management data from the Traffic Operations Center were considered, but not used due to various reasons. Thus, its conclusions were mostly grounded on either the information from other states or from nationwide average data published by the Federal Highway Administration.

To ensure the quality of evaluation and also to consider the opening of the Statewide Operations Center (SOC) in August 1995, all members involved in the evaluation study concluded that a reliable analysis should be based on the actual performance data from the CHART program. Thus, the 1996 incident management data were collected and used in the pilot evaluation analysis conducted jointly by the University of Maryland and MSHA staff (Chang and Point-Du-Jour, 1998). This pioneering study inevitably faced the difficulty of having a data set
with sufficient information for analysis, as it was the first time for CHART to identify and organize all previous performance records for a rigorous evaluation.

The evaluation for the 1997 CHART performance had the advantage of receiving relatively rich information, including all 12 month incident management reports from the SOC, TOC-3 (located at the proximity of the Capital Beltway) and TOC-4 (located near the Baltimore Beltway). Also provided were the 1997 accident reports from Maryland State Police for secondary incident analyses.

Unlike all previous studies, the data set available for the year 1999 evaluation has increased substantially as CHART has started to record its emergency response operations from 1999. This includes major incidents involving the police and other support units in its extensive incident reports as in previously years, but also those incidents or driver assistance handled by SHA alone in concise incident reports.

For instance, TOC-3 in the year of 1999 reported to have responded to 1,134 major incidents and 19,550 non-major incidents or assistance requests from drivers. TOC-4 claimed to have contended with 223 major incidents and 6179 non-major in the same year. SOC, mainly for major incident coordination, handled 909 incident response operations during the entire year 1999.

Improving from its mechanism established in the year 1999, CHART has made a significant progress on both the quality and quantity of its incident data collection and recording work. In the year 2000, SOC handled 786 major crashes, whereas TOC-3 reported to manage 17,379 non-major incidents and/or assistance to drivers and 1,165 major incidents. At the comparable level, TOC-4 in the year 2000 also handled a large volume of incidents, including 13,771 non-major incidents and/or driver assistance, and 500 major accidents.

TOC-5, operated only during the summer months, also responded to 1,290 non-major incidents between April and October of the year 2000. Overall, the total number of CHART incident reports available for analysis has increased from 27,987 in the year 1999 to 34,891 in the year 2000, mostly due to the full year data collection by TOC-4.
Evolution of Evaluation Work

Over the past three years, CHART has consistently worked on improving its data recording for both major and minor incidents. Hence, the quantity and quality of incident reports available for performance analysis have increased substantially since the year 1999.

In response to the improvement in data availability, the evaluation work has also been evolved from its infancy of using all available data to a new stage of demanding data quality and employing only reliable information in the performance as well as benefit analysis. Thus, the performance evaluation report for CHART in the year 2000 has included more information in the data quality review in Chapter 2. This is aimed at ensuring a sustained improvement in the quality of incident related data so that all potential benefits due to efficient CHART operations can be estimated reliably and reported to the general public as well as policy makers.

Distribution of Incidents

The evaluation methodology was developed to take full advantage of those available data having the acceptable quality. It started with analyses of incident characteristics by the blockage frequency, duration, and blocked lanes.

With respect to severe incidents, the analysis results indicate that there were a total of 3,195 incidents having one-lane blockage, 2,169 incidents causing two-lane closures, and about 825 incidents blocking more than two lanes.

Overall, the incidents, including shoulder-lane blockage, on freeways were mostly distributed along four major commuting corridors, where I-495/95 experienced a total of 11,404 incidents; I-695, I-270 and I-95 had 7,704, 1,767 and 2,779 incidents, respectively, in the year 2000. Thus, CHART had responded to, on average, 33 incidents per day along I-495/95 alone, and 21, 5 and 8 incidents along the other three main commuting freeways.

It, however, should be mentioned that most incidents on major commuting freeways did not block traffic for more than one hour. For instance, 96.4 percent of incidents responded by TOC-3 in the year 2000 were recovered in less than one hour. A similar pattern also exists in the TOC-4 data, where about 94.2 percent of incidents had the duration for less than one hour. Conceivably, this could be attributed to both the nature of incidents and most likely the efficient response of CHART emergency operations units.
Note that in comparison with other highways, drivers on I-495/95 clearly had been caught in a long incident blockage much more often than others. There were a total of 439 incidents in 2000 on I-495/95 and other freeways covered by TOC-3 lasting over one hour, and 149 of those blocking traffic for more than 2 hours.

In brief, it is clear that the highway network covered by CHART has been plagued by a high frequency of incidents, ranging from about 20 minutes to more than 2 hours. Those incidents were apparently one of the primary contributors to the traffic congestion in the entire region, especially on those major commuting highway corridors such as I-495/95, I-695, I-270 and I-95.

Efficiency of Operations

In evaluating the efficiency of an incident management program, it is essential to cover the following three vital aspects: detection, response, and recovery of traffic conditions. Unfortunately, data needed for performing the detection and complete response time analysis are not yet available under the current CHART operations.

One of the indicators related to the detection is the response time to a reported incident. It was found to be about 14.96 minutes for the TOC-3, 15.43 minutes for TOC-4, and 19.14 minutes for SOC. The MSHA patrols and Maryland State Police (MSP) were the main sources for detecting and reporting incidents for CHART.

To understand the contribution of the incident management program, this study has computed and compared the average incident clearance time between responded and non-responded incidents. For instance, for those two lane-blockage incidents SHA patrol did not respond to, the average operation time was about 79.67 minutes, significantly longer than the average of 35.53 minutes for the same type of two-lane blockage incidents managed by CHART/MSHA (i.e., with SHA patrols).

Taking into account all types of incidents, the average incident duration with and without the management by SHA response units was found to be 33 minutes and 77 minutes, respectively. Thus, based on the available record in the year 2000, the operations of CHART/MSHA resulted in about 57 percent reduction on the average incident duration.

It should be mentioned that the average incident duration for those without assistance from CHART/MSHA, has also been reduced significantly across all types of lane-blockage incidents.
in the year 2000. For instance, the average non-responded incident duration was 77 minutes in the year 2000, much shorter than the average of 93 minutes in the year 1999. This seems to reflect the fact that the need to efficiently respond to incidents so as to minimize its impacts on the driving populations has been well recognized by all responsible agencies.

**Resulting Benefits**

The benefits attributed to the CHART/MSHA operations that were estimable directly from the available data include: assistance to drivers, reduction in driver delay time, fuel consumption, emissions, and secondary incidents. The CHART/MSHA operations in 2000 responded to a total of 6,189 lane blockage incidents, and provided assistance to highway drivers 19,257 times that may otherwise cause incidents or rubbernecking effects of delay to the highway traffic.

The direct benefits of reduction in delay time and fuel consumption were estimated according to the methodology developed in 1999. It has been found that the operations of CHART/MSHA in 2000 resulted in a total delay time reduction of 24.24 million vehicle-hours, and total fuel consumption reduction of approximately 4.1 million gallons. The operations of CHART in 2000 also contributed to a potential reduction of 1267 secondary incidents.

This evaluation study has also attempted to quantify the benefits of reducing potential lane-changes related crashes at lane-blockage locations due to the operations of CHART/MSHA. Based on the field data observed in the I-95/495 and our developed statistical model, it has been found that about every 5000 forced lane changes at lane-closure location in the peak hours is likely to cause one crash. Accordingly, the total number of potentially reduced crashes due to the efficient operations of CHART/MSHA on the I-95/495 alone in year 2000 could be up to 297.

**Conclusions, Recommendations, and Further Development.**

The primary recommendations based on the performance of CHART in the year 2000 are summarized below:

*Continuing the efforts on training operators to effectively record all essential operations related data.* -- As reported in Chapter-2, data quality evaluation, many of those incident reports in the year 2000 were found to have a large number of either missing or incomplete items. Some of those missing data (e.g., incident blockage duration) are often very critical in the benefit computation.
Automating the current incident report procedures that can offer both the assistance to and the flexibility for operators to record all vital information that are essential for improving the operations efficiency and justifying the resulting benefits. -- Although the overall data quality has been improved significantly in the year 2000, many vital information items in the incident reports, such as assistance to driver requests, were either undocumented or classified into “others”.

Conducting the current evaluation and benefit analysis on a quarterly basis so that all performance related results can be fed back to CHART in a timely manner to continuously improve its operations.--- All timely reported benefits may also be useful for CHART to best allocate the available resources and sustain the support from both the general public and state policymakers.

Developing an integrated performance database that consists not only incident reports, but also all data, such as traffic volume, needed for direct benefit computation or estimation of safety related contribution, including potentially reduction in secondary incidents and lane-changing related accidents due to a quick removal of stationary vehicles or some debris on highway travel lanes.

Improving the use of freeway service patrols and dynamically assigning their locations based on both the spatial distribution of incidents along freeway segments and the probability of having incidents at different times of a day so, that the average response time can be reduced as expected.

Integrating the incident performance evaluation module with the CHART’s operations and information management system so, that the evaluation module can not only generate the up-to-date CHART performance report as needed, but also an integrated component of the entire operations.
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Chapter 1 INTRODUCTION

1.1 Background

CHART (Coordinated Highways Action Response Team) is the highway incident management program of the Maryland State Highway Administration. Initiated in the mid 80’s as “Reach the Beach”, it has extended to a statewide program headquartered in Hanover, Maryland where the integrated Statewide Operations Center (SOC) is located. The SOC is also supported by three satellite traffic operations centers (TOC), one being seasonal. Most of the field operations of CHART are also supported by the maintenance units. The current network covered by CHART consists of both statewide freeways and major arterials.

CHART is comprised of four major components: traffic monitoring, incident response, traveler information, and traffic management. The objective of this study was to assess the effectiveness of CHART’s operations, including its incident detection, response, and traffic management on the interstate freeways as well as major arterials. The assessment work also covers the CHART benefits estimation as such benefits are essential for MSHA to receive the sustained support for all their on-going programs from both the general public and state policy makers.

The first attempt to evaluate the performance of CHART was made by COMSIS in 1996, which, however, was derived from either other states or the nationwide statistics by FHWA. A subsequent study of CHART’s performance in 1996 was conducted by the University of Maryland based on the 1996 incident records from CHART, and accident reports from the state police office (Chang and Point-Du-Jour, 1996). However, since it was the first time for CHART to use its historical incident management record for performance evaluation, some valuable information was not available for analysis.

The evaluation for the 1997 CHART performance had the advantage of receiving relatively rich information, including all 12 months incident management reports from the SOC, TOC-3 (located at the proximity of the Capital Beltway) and TOC-4 (located near the Baltimore Beltway). Also provided were the 1997 accident reports from Maryland State Police for secondary incident analyses. The data set for the 1999 evaluation had increased substantially as CHART has started to record its own emergency response operations from 1999, including not only major incidents involving the police and other support units in its extensive incident reports.
(named Long forms) as in previously years, but also those incidents or driver assistance handled by SHA alone in concise incident reports (named Short forms).

For instance, TOC-3 reported to have responded to 1134 major incidents, and 19,550 non-major incidents or driver assistance in 1999. TOC-4 claimed to have contended with 223 major incidents over the entire 12 months in 1999, and 6,171 non-major incidents as well as driver assistance between September and December of the same year. SOC, mainly for coordination of incident management, has handled 909 major incident response operations in 1999. Thus, a total of 27,987 incident reports were used in the 1999 CHART performance evaluation. In addition, the 1999 accident reports from Maryland State Police were employed for computation of potential secondary incidents.

1.2 Technical Terms

Figure 1.1 illustrates the definition of major parameters necessary for evaluating the effectiveness and efficiency of an incident management system. It should be mentioned that in most cases the incident occurrence time is not available except those detected by CCTV. Another parameter that is difficult to measure is the preparation time – the time period between detection of an incident and dispatch of the response units. Thus, this evaluation does not include the efficiency of incident detection and response preparation.

**Figure 1.1: Graphical Illustration of Technical Terms Associated with Incident Operations**
1.3 Data Available for 2000 Evaluation

Improving from its mechanism established in the year 1999, CHART has made a significant progress on both the quality and quantity of its incident data collection and recording work. In the year 2000, SOC was in charge 786 cases major accidents, whereas TOC-3 reported to have managed 17,379 non-major incidents and/or assistance to drivers and 1,165 major incidents. At the comparable level, TOC-4 in the year 2000 also handled a large volume of incidents, including 13,771 non-major incidents and/or driver assistance, and 500 major accidents.

TOC-5, operated only during summer months also, responded to 1,290 non-major incidents between April and October of the year 2000. Overall, the total number of CHART incident reports available for analysis has increased from 27,987 in the year 1999 to 34,891 in the year 2000, mostly due to the full year data collection by TOC-4. A summary of the data collected by CHART in the year 2000 is presented in Table 1.1.

<table>
<thead>
<tr>
<th>Division</th>
<th>Report Type</th>
<th>2000</th>
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<th>Inc. Type</th>
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<td>12 months</td>
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<tr>
<td></td>
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<tr>
<td></td>
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<td>12 months</td>
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</table>

In addition to the above incident data, this evaluation study also employs the information of traffic volumes from MSHA data base and accident record from the MSP for computations of delay and fuel consumption reduction as well as potential reduction in secondary incidents.
1.4 Evaluation Methodology

Following the same methodology developed in previous evaluations, this study has divided the year 2000 CHART evaluation into the following principal tasks:

Task-1: Assessing Data Sources and Data quality
- Identifying the sources of the data and evaluating their quality.
- Analyzing available data and classifying missing parameters.

Task-2: Statistics Analysis and Comparison
- Performing the comparison analysis based on the data available in the years 1999 and 2000 within following target areas:
  - incident characteristics;
  - incident detection efficiency;
  - distribution of detection sources;
  - incident response efficiency; and
  - effectiveness of incident traffic management.

Task-3: Benefit Analysis.
- reduction in total delay time due to CHART/SHA operations;
- reduction in fuel consumption due to CHART/SHA operations;
- reduction in total emissions due to CHART/SHA operations;
- reduction in secondary incidents due to CHART/SHA operations;
- reduction in potential accidents due to the efficient removal of stationary vehicles in travel lanes by CHART/SHA response team;

Note that the above tasks do not include the estimation of some indirect impacts such as the reduction in travel time and fuel savings from potentially reduced secondary incidents, the associated medical and legal costs, and improvement of the commuting environment. This is understandably due to the fact that most of such data are not available at that stage. Thus, the results of this study can be used not only to picture the approximate benefits and performance of CHART, but also to assist MSHA in identifying and collecting additional critical data for future analysis.
1.5 Literature Review

Despite the increasing investment on incident management by most state highway agencies, comprehensive evaluations for assessing effectiveness of such programs, however, are not available in the literatures. Some related studies reported in the literature are briefly reviewed below.

Carson et al. (1999) used quantified information, such as duration of detection/reporting, response and clearance, to investigate the effectiveness of incident management systems in Washington State. They calculated the monetary savings per incident by considering the reduction in average duration per incident from 1994 to 1995, and the value of time per vehicle-hour of delay from the traffic simulation results presented by Garrison and Mannering (1990). They did not compute the reduction in delays precisely nor did they compare the incident duration with and without the response of an incident management system. The public opinions and personnel input from relevant agencies were collected to estimate the perceived benefits.

Cuciti et al. (1993) performed an evaluation of Patrol Pilot Program designed to detect and remove disabled vehicles from the roadway quickly so as to minimize the resulting congestion backups for the I-25 corridor in Denver. In the entire evaluation, the authors focused on some critical issues such as: the incident response implementation procedures, incident types and services provided by the patrols, levels of motorist satisfaction with the program, comparison of alternative service delivery modes and their impacts on traffic conditions. However, it did not include the estimation of the direct and indirect benefits such as fuel consumption and reduction in secondary incidents.

Amos et al. (1995), in their study for installation of an incident management system on M4 in Sydney, Australia, proposed that evaluation of an incident management system should consist of project objectives, the evaluation approach, a clear and realistic measurement system and definition of the data requirements to measure the before and after condition. But the study was mainly at the conceptual level rather than actually performing the evaluation.

Along the same line, Karimi et al. (1993) pointed out four important elements of incident management system for Santa Monica Smart Corridor, which are detection, verification, response and monitoring. They proposed that response plans must be dynamic to reflect the evolving characteristics of the incident. To do so, incident management subsystem should monitor both the response plan and the incident, and may modify the response based on any changes that are
detected. However, they neither did actual evaluation of the system nor discussed the necessary data for evaluating such a system.

Skabardonis et al. (1996) indicated that some factors such as: incident frequency and characteristics, freeway operational characteristics, the number of tow trucks involved, hours of operations and dispatching strategy are critical to the effectiveness of freeway service patrol systems. They collected information on incidents, such as types of incident, number of lanes affected, vehicles involved (type, color), location (direction, lane, upstream or downstream to the nearest exit), time first witnessed an incident and arrival and departure times of tow trucks or patrols.

Additional data were gathered from a computer-aided dispatch system, tow truck companies and patrol records. They developed a methodology to estimate incident delays based on the travel time difference under normal and incident conditions using data from loop detectors. The savings in delays and fuel consumption were converted to monetary benefits. They also measured average time saving for vehicles assisted by freeway service patrol.
Chapter 2 DATA QUALITY FOR THE EVALUATION STUDY

The purpose of this chapter is to illustrate the quality of data for the CHART 2000 performance evaluation study and compare it with the quality of the data from the year 1999. The analysis and comparison of data quality reported in this chapter will be focused on the following critical information items:

- available data for analysis;
- available data for analysis of detection sources;
- type of incidents (i.e., major, minor, driver assistance) available for analysis;
- available data for analyzing incident blockage impacts on traffic conditions;
- available data for analysis of incident locations; and
- available data for analyzing incident response efficiency and effectiveness.

2.1 Available Data

As CHART operators have substantially improved both the quality and quantity of its incident data collection, this study has received a large volume of data (i.e., 34,891 reports) for analyzing CHART’s performance in the year 2000. Most of those incidents, including either minor traffic blockages or assistance requests from drivers, were reported in the following concise short form (see Figure 2-1).

Figure 2.1: A Sample of the Short Form for Minor Incidents
To ensure the quality of this analysis and also to serve as the basis for evaluating the future data collection efforts, a detailed data quality analysis with respect to all available incident reports has been performed prior to the evaluation of operations efficiency and resulting benefits.

The data quality evaluation is focused primarily on the following critical information items:
- available data and detection sources;
- distribution of incidents;
- nature of incidents;
- road name of incident sites;
- location of incidents;
- lane/shoulder blockage;
- received/dispatched time;
- arrival time of response units; and
- incident cleared time.

Figures 2.2 and 2.3 illustrate the availability of the above critical data items in the year 1999 and 2000 CHART performance evaluation.
Figure 2.2: A Statistical Summary for Key Data Items Available for Evaluation

Figure 2.3: A Statistical Summary for Key Data Items Available for Evaluation (TOC-3 vs. TOC-4)
2.2 Detection Source

This set of data is necessary to evaluate the effectiveness of various detection means. As shown in Figure 2.2, more than 87% of the incident reports in the year 2000 contain this vital information for the ensuing performance evaluation.

2.3 Type of Incident

The incident reports provided by SOC for the year 2000 cover a total of 786 major incidents over the entire year, slightly less than the total number of 909 in the year 1999.

The total number of incidents managed by each operations center is classified as follows:

- **Extensive incident reports** for major incidents that involved police and other CHART response units (in long forms):
  - 1,165 in the year 2000;
  - 1,134 in the year 1999.

- **Concise incident reports** for minor incidents and driver assists (in short forms):
  - 17,379 in the year 2000;

- **Available data coverage period**: entire 12 months in both the year of 2000 and 1999.

Note that both Driver Assistance and Minor Incident responses codes 1046 and 1050, respectively, were with short forms. The data collected by TOC-3 during last two years with respect to incident types is summarized in the Table 2.1 below.

<table>
<thead>
<tr>
<th>Incident type</th>
<th>2000</th>
<th>% of total</th>
<th>1999</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1046</td>
<td>10,513</td>
<td>60.5</td>
<td>17,049</td>
<td>87.2</td>
</tr>
<tr>
<td>1050</td>
<td>4,066</td>
<td>23.4</td>
<td>2,319</td>
<td>11.9</td>
</tr>
<tr>
<td>Unknown</td>
<td>2,800</td>
<td>16.1</td>
<td>182</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>17,379</td>
<td>100</td>
<td>19,550</td>
<td>100</td>
</tr>
</tbody>
</table>

Similarly, for TOC-4 the data available for analysis include:

- **Extensive incident reports** for major incidents that involved police and other CHART response units:
  - 500 in the year 2000;
  - 223 in the year 1999.
- **Concise incident reports** for minor incidents and driver assistance:
  - 13,771 in the year 2000;
  - 6,171 in the year 1999.

- **Available data coverage period:** entire 12 months in 2000 and 4 months (September to December) in 1999.

A summary of incidents managed by TOC-4 is given in the Table 2.2.

<table>
<thead>
<tr>
<th>Incident type</th>
<th>2000</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Inc.</td>
<td>% of total</td>
</tr>
<tr>
<td>1046</td>
<td>8,874</td>
<td>64.5%</td>
</tr>
<tr>
<td>1050</td>
<td>2,042</td>
<td>14.8%</td>
</tr>
<tr>
<td>Unknown</td>
<td>2,855</td>
<td>20.7%</td>
</tr>
<tr>
<td>Total</td>
<td>13,771</td>
<td>100%</td>
</tr>
</tbody>
</table>

A review of the data collected by TOC-5, operated from April through October, indicates that its quality and recording format were incompatible with the other three major operational centers. Due to the concern that inclusion of the small volume but poor quality data from TOC-5 may bias the statistical estimation of all target benefits, the study has decided to focus our analysis on those from SOC, TOC-3, and TOC-4.

A summary of all incidents managed by both TOC-3 and TOC-4 in the year 2000 is presented in Table 2.3.

<table>
<thead>
<tr>
<th>Incident type</th>
<th>2000</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total number</td>
<td>percentage</td>
</tr>
<tr>
<td>1046</td>
<td>19,387</td>
<td>62.2%</td>
</tr>
<tr>
<td>1050</td>
<td>6,108</td>
<td>19.6</td>
</tr>
<tr>
<td>Unknown</td>
<td>5,655</td>
<td>18.2</td>
</tr>
<tr>
<td>Total</td>
<td>31,150</td>
<td>100</td>
</tr>
</tbody>
</table>

### 2.4 Data Available for Classifying Incident Nature

This type of data is to be used to classify the nature of incidents, including major accidents causing lane blockages, minor incidents such as flat tires, shortage of gas, or unattended vehicles
in the travel lane. It has been found that about 50 percent of incident reports in the year 2000 provided this type of information, compared to only 29 percent in the year 1999 data. Seemingly, CHART has made a significant improvement in this regard, but much remains to be done.

2.5 Data Available for Identifying the Road Name and Location of Incidents

The road name and location associated with each incident is used to the analysis of the spatial distribution of incidents and identification of hazardous freeway segments. The availability of such information in the TOC-3 and the entire incident reports are summarized below:

Table 2.4: Available Data for Identifying Road Name and Location in the Year of 2000 and 1999 from the TOC-3 Record.

<table>
<thead>
<tr>
<th>Incident type</th>
<th>Road Name</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Inc.</td>
<td>Available %</td>
</tr>
<tr>
<td>1046</td>
<td>10,513</td>
<td>58.4</td>
</tr>
<tr>
<td>1050</td>
<td>4,066</td>
<td>21.5</td>
</tr>
<tr>
<td>Unknown</td>
<td>2,800</td>
<td>9.6</td>
</tr>
<tr>
<td>Total</td>
<td>17,379</td>
<td>89.5</td>
</tr>
</tbody>
</table>

Table 2.5: Available Data for Identifying Road Name and Location in the Year of 2000 and 1999

<table>
<thead>
<tr>
<th>Incident type</th>
<th>Road Name</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Inc.</td>
<td>Available %</td>
</tr>
<tr>
<td>1046</td>
<td>19,387</td>
<td>57.8</td>
</tr>
<tr>
<td>1050</td>
<td>6,108</td>
<td>17.6</td>
</tr>
<tr>
<td>Unknown</td>
<td>5,655</td>
<td>12.7</td>
</tr>
<tr>
<td>Total</td>
<td>31,150</td>
<td>88.1</td>
</tr>
</tbody>
</table>
2.6 Lane/Shoulder Blockage Information

The information regarding the number of lanes or shoulder lanes being blocked is essential for computation of additional delay and fuel consumption due to incidents. In the dataset provided by TOC-3, only 9.7% of those available 1046 incident reports have clearly indicated the type of lane/shoulder blockage. In the 1050 (accidents) incidents reports, there are about 6.1% of those reliably describing the resulting lane blockage. Among those unspecified type of incidents, about 11.5% resulted in lane blockages. Overall, only 27.3% of those reports provided by TOC-3 in the year 2000 indicated the resulting number of lane blockage, compared to 26.6% in the year 1999.

The data from TOC-4 seems to have a better quality on this regard, about 40.6 percent of its incident report clearly indicating the resulting number of lane blockage. Overall, in the entire data set for the year 2000 analysis, it has a total of 10,341 (about 33.2%) reports that contain the information of lane blockage details for further analysis.

2.7 Data for Computing Dispatched, Arrival, and Clearance Times

Dispatched, arrival, and clearance time data are essential for evaluating the efficiency of the incident and response operations. Without such information many potential benefits of CHART operations would be impossible to estimate reliably. The overall data available for computing these critical performance measures, from both TOC-3 and TOC-4, is summarized in Tables 2.7 and 2.8.

<table>
<thead>
<tr>
<th>Inc. Type</th>
<th>No. of Inc.</th>
<th>2000</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Received</td>
<td>Dispatched</td>
<td>Arrived</td>
<td>Cleared</td>
</tr>
<tr>
<td>1046</td>
<td>10,513</td>
<td>10,485</td>
<td>191</td>
<td>1,383</td>
</tr>
<tr>
<td>1050</td>
<td>4,066</td>
<td>4,052</td>
<td>78</td>
<td>631</td>
</tr>
<tr>
<td>Unknown</td>
<td>2,800</td>
<td>2,768</td>
<td>107</td>
<td>217</td>
</tr>
<tr>
<td>Total</td>
<td>17,379</td>
<td>17,305</td>
<td>376</td>
<td>2,231</td>
</tr>
<tr>
<td>% of Total</td>
<td>100</td>
<td>99.6</td>
<td>2.2</td>
<td>12.8</td>
</tr>
<tr>
<td>Corresponding % in 1999</td>
<td>N/a</td>
<td>37.7</td>
<td>10.3</td>
<td>42.4</td>
</tr>
</tbody>
</table>
Table 2.7: Availability of Response Efficiency Related Information - from TOC-4.

<table>
<thead>
<tr>
<th>Inc. Type</th>
<th>No. of Inc.</th>
<th>2000</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Received</td>
<td>Dispatched</td>
<td>Arrived</td>
<td>Cleared</td>
</tr>
<tr>
<td>1046</td>
<td>8,874</td>
<td>5,652</td>
<td>1,199</td>
<td>3,880</td>
<td>6,505</td>
</tr>
<tr>
<td>1050</td>
<td>2,042</td>
<td>1,251</td>
<td>470</td>
<td>1,037</td>
<td>1,434</td>
</tr>
<tr>
<td>Unknown</td>
<td>2,855</td>
<td>1,614</td>
<td>354</td>
<td>1,079</td>
<td>1,262</td>
</tr>
<tr>
<td>Total</td>
<td>13,771</td>
<td>8,517</td>
<td>2,023</td>
<td>5,996</td>
<td>9,201</td>
</tr>
<tr>
<td>% of Total</td>
<td>100</td>
<td>61.8</td>
<td>23.8</td>
<td>43.5</td>
<td>66.8</td>
</tr>
<tr>
<td>Corresponding % in 1999</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
</tbody>
</table>

Table 2.8: Availability of Response Efficiency Related Information - from the Entire Data Set.

<table>
<thead>
<tr>
<th>Inc. Type</th>
<th>No. of Inc.</th>
<th>2000</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Received</td>
<td>Dispatched</td>
<td>Arrived</td>
<td>Cleared</td>
</tr>
<tr>
<td>1046</td>
<td>19,387</td>
<td>16,137</td>
<td>1,390</td>
<td>5,263</td>
<td>14,930</td>
</tr>
<tr>
<td>1050</td>
<td>6,108</td>
<td>5,303</td>
<td>548</td>
<td>1,668</td>
<td>3,398</td>
</tr>
<tr>
<td>Unknown</td>
<td>5,655</td>
<td>4,382</td>
<td>461</td>
<td>1,296</td>
<td>2,059</td>
</tr>
<tr>
<td>Total</td>
<td>31,150</td>
<td>25,822</td>
<td>2,399</td>
<td>8,227</td>
<td>20,387</td>
</tr>
<tr>
<td>% of Total</td>
<td>100</td>
<td>82.9</td>
<td>9.3</td>
<td>26.4</td>
<td>65</td>
</tr>
</tbody>
</table>

A Comparison of the above data items available from TOC-3 between the year 1999 and the year 2000 is presented on Figure 2.4.

![Graphical Comparison of Data Availability between the Year 2000 and Year 1999](image)
In summary, CHART has made a significant progress in documenting its performance, keeping incident operations related information. But, much remains to be improved as evidenced in the above statistics of data quality evaluation. CHART operators should be advised that their contribution to mitigating traffic congestion, assisting driving populations, and improving the overall driving environments of the highway networks would not be understated only if more quality data are available for analysis and justifying the resulting benefits.
Chapter 3 ANALYSIS OF INCIDENT CHARACTERISTICS

To provide a clear picture for both incident management and traffic safety improvement, the evaluation work starts with a comprehensive analysis of the spatial distribution of incidents and their key characteristics, including:

- Distribution of incidents by weekday and weekend;
- Distribution of incidents by peak and off-peak hours;
- Distribution of incidents by road;
- Distribution of incidents by location;
- Distribution of incidents by lane blockage;
- Distribution of incidents by blockage duration.

With the above information, one can certainly better design the incident management strategies, including: the distribution of patrol vehicles around freeway segments of a high incident frequency; assessing the impact areas under the average and the worst incident scenarios; and identifying hazardous highway segments from both the safety and operations perspectives.

3.1 Distribution of Incidents by Weekday and Weekend, by Peak and Off-peak Hours

This study has also analyzed the distribution of incidents between weekdays and weekends. As shown in Figure 3.1, it is expected that most incidents, about 98%, occurred on weekdays. Thus, more resources and manpower are required to manage those incidents effectively on weekdays than on weekends. The patrol vehicles or response units and operators in the control center may be reduced on weekends so as to minimize the operating costs of the Program.
As defined in the 1999 CHART evaluation, peak hours in this study were set to be from 7:00 AM to 9:30 AM and from 4:00 PM to 6:30 PM. About 27% of overall incidents reported in the year 2000 data set occurred during such congested periods, slightly higher than that of 22% in the year 1999 (see Figure 3.2).

Figure 3.1: Distribution of Incidents by Weekdays and Weekends in the Year 2000

Figure 3.2: Distribution of Incidents by Peak & Off-peak Periods in the Year 2000
3.2 Distribution of Incidents by Road

Figures 3.3 and 3.4 present the distribution of incident frequency by road, where minor incidents and assistance to drivers were derived from Short forms (Figure 3.3), and major incidents/accidents from Long forms (figure 3.4). It is clear that the four major commuting freeways, I-495/95 (Capital Beltway), I-695 (Baltimore Beltway), I-95 (from Delaware border to Capital Beltway) and I-270, had a very large number of incidents, significantly higher than all other highways. I-495/95 experienced a total of 11,404 incidents; I-695, I-95 and I-270 had 7,704, 2,779 and 1,767 incidents, respectively, in the year 2000.

Figure 3.3: Distribution of Minor Incidents by Road in the Year 2000 (Short Forms)
Figure 3.4: Distribution of Major Incidents by Road in the Year 2000 (Long Forms)

The frequency distribution of incidents indicates that CHART had responded to about 33 incidents per day for I-495/95 alone, about 21 incidents per day along I-695, 8 and 5 incidents per day, respectively, for I-95 and I-270. Other major freeways, such as I-70, I-83, I-795, US-50 and MD-295, also experienced a large number of incidents in the year 2000. A comparison of incident distributions by road between the year of 1999 and 2000 is shown in Figure 3-5.

Figure 3.5: Comparison of Incident Distributions by Road in the Year of 2000 and 1999
It should be noted that both I-95 and I-270 are connected to I-495/95, and are the main contributors of traffic congestion on I-495 during daily commuting periods. Due to the high traffic demand on I-495, any of its severe incidents is very likely to have vehicles queued back to both I-95 and I-270, thus causing serious congestion on those two freeways. Such interdependent nature of incidents between primary commuting freeways should be taken into account in prioritization and implementation of incident management strategies.

Conceivably, contending with such a high frequency of incidents on all those major commuting freeways is a challenging task from either the traffic safety or congestion mitigation perspective. Some effective remedies to improve both the driving conditions and driver behavior shall be regarded as priority tasks. Since those incidents also resulted in lane blockage on congested freeways, all agencies responsible for highway operations and safety ought to take the implementation of an efficient incident management program as one of their most urgent tasks.

### 3.3 Distribution of Incidents by Location

To best allocate patrol vehicles and response units to hazardous highway segments, this study has also analyzed the distribution of incidents by location along major freeways. By grouping the total number of incidents, including severe incidents and various types of driver assistance, between two consecutive exits as an indicator, Figure 3.6 shows their geographical distribution on I-495/95.

Notably, the highest number of incidents occurred between Exits 27 and 28, representing the I-495 segment between MD-202 (Landover Rd), MD-704 and US-50. This particularly hazardous segment experienced a total of 619 incidents in 2000, nearly two incidents per day. Freeway segments between Exits 1 and 2, 19 and 20, 25 and 27, also experienced a comparable level of incident frequency. The average number of incidents per day was 395 in the year 2000 and 397 in the year 1999.
Figure 3.6: Distribution of Incidents by Location on I-495/I-95 (in Maryland)

Figures 3.7 and 3.8 present the distribution of incidents by locations on I-95, and I-270. The highest number of incidents on I-95 occurred between Exits 29 and 33, and it had a total of 498 in the year 2000 compare to 590 in the previous year. The segment near the interchange of I-495 and I-95 had the second largest number of incidents, i.e., 454 in the year 2000 compared to 368 in the year 1999. The segment of I-95 between exits 47 and 49 (between I-195 and I-695) experienced the third largest number of incidents, about 424 incidents in the year 2000.

![Figure 3.6: Distribution of Incidents by Location on I-495/I-95 (in Maryland)](image)

Figure 3.7: Distribution of Incidents by Location on I-95

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of Incidents (2000)</th>
<th>Number of Incidents (1999)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exits 27 &amp; 29</td>
<td>454</td>
<td>368</td>
</tr>
<tr>
<td>Exits 29 &amp; 33</td>
<td>498</td>
<td>498</td>
</tr>
<tr>
<td>Exits 33 &amp; 35</td>
<td>590</td>
<td>590</td>
</tr>
<tr>
<td>Exits 35 &amp; 38</td>
<td>190</td>
<td>190</td>
</tr>
<tr>
<td>Exits 38 &amp; 41</td>
<td>418</td>
<td>418</td>
</tr>
<tr>
<td>Exits 41 &amp; 43</td>
<td>186</td>
<td>186</td>
</tr>
<tr>
<td>Exits 43 &amp; 46</td>
<td>174</td>
<td>174</td>
</tr>
<tr>
<td>Exits 46 &amp; 47</td>
<td>215</td>
<td>215</td>
</tr>
<tr>
<td>Exits 47 &amp; 49</td>
<td>428</td>
<td>428</td>
</tr>
<tr>
<td>Exits 49 &amp; 50</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>Exits 50 &amp; 51</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Exits 51 &amp; 52</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Exits 53 &amp; 54</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Exits 55 &amp; 56</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exits 57 &amp; 58</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exits 59 &amp; 60</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Exits 61 &amp; 62</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exits 63 &amp; 64</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exits 65 &amp; 66</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exits 67 &amp; 68</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exits 69 &amp; 70</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
With respect to I-270, its segment between Exits 1 and 2 on I-270 was reported to have the highest number of incidents (252 in the year 2000), and the incident frequency appears to decrease linearly with its distance from the Capital Beltway.

<table>
<thead>
<tr>
<th>Exit Pair</th>
<th>2000</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exits 1 &amp; 2</td>
<td>344</td>
<td>252</td>
</tr>
<tr>
<td>Exits 2 &amp; 4</td>
<td>258</td>
<td>158</td>
</tr>
<tr>
<td>Exits 4 &amp; 5</td>
<td>171</td>
<td>111</td>
</tr>
<tr>
<td>Exits 5 &amp; 6</td>
<td>111</td>
<td>144</td>
</tr>
<tr>
<td>Exits 6 &amp; 8</td>
<td>185</td>
<td>103</td>
</tr>
<tr>
<td>Exits 8 &amp; 9</td>
<td>103</td>
<td>83</td>
</tr>
<tr>
<td>Exits 9 &amp; 10</td>
<td>16</td>
<td>144</td>
</tr>
<tr>
<td>Exits 10 &amp; 11</td>
<td>144</td>
<td>113</td>
</tr>
<tr>
<td>Exits 11 &amp; 13</td>
<td>113</td>
<td>83</td>
</tr>
<tr>
<td>Exits 13 &amp; 15</td>
<td>144</td>
<td>83</td>
</tr>
<tr>
<td>Exits 15 &amp; 16</td>
<td>144</td>
<td>93</td>
</tr>
<tr>
<td>Exits 16 &amp; 18</td>
<td>144</td>
<td>144</td>
</tr>
<tr>
<td>Exits 18 &amp; 22</td>
<td>144</td>
<td>144</td>
</tr>
<tr>
<td>Exits 22 &amp; 26</td>
<td>144</td>
<td>144</td>
</tr>
<tr>
<td>Exits 26 &amp; 31</td>
<td>144</td>
<td>144</td>
</tr>
<tr>
<td>Exits 31 &amp; 32</td>
<td>144</td>
<td>144</td>
</tr>
</tbody>
</table>

**Figure 3.8: Distribution of Incidents by Location on I-270**

With more data available from TOC-4 in the year 2000, this study has also analyzed the distribution of incidents along I-695. Its high-incident segments, as shown in Figure 3.9, lie between exits 16 and 17 (near I-70), exits 18 and 19 (near I-795), and exits 22 and 23 (near I-83).

<table>
<thead>
<tr>
<th>Exit Pair</th>
<th>2000</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exits 1 &amp; 2</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Exits 3 &amp; 4</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>Exits 5 &amp; 6</td>
<td>47</td>
<td>47</td>
</tr>
<tr>
<td>Exits 7 &amp; 8</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>Exits 9 &amp; 10</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Exits 11 &amp; 12</td>
<td>153</td>
<td>153</td>
</tr>
<tr>
<td>Exits 13 &amp; 14</td>
<td>102</td>
<td>102</td>
</tr>
<tr>
<td>Exits 15 &amp; 16</td>
<td>133</td>
<td>133</td>
</tr>
<tr>
<td>Exits 17 &amp; 18</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 19 &amp; 20</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 21 &amp; 22</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 23 &amp; 24</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 25 &amp; 26</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 27 &amp; 28</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 29 &amp; 30</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 31 &amp; 32</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 33 &amp; 34</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 35 &amp; 36</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 38 &amp; 39</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 40 &amp; 41</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Exits 42 &amp; 43</td>
<td>208</td>
<td>208</td>
</tr>
</tbody>
</table>

**Figure 3.9: Distribution of Incidents by Location on I-695**
3.4 Distribution of Incidents by Lane Blockage Type

Figure 3.10 illustrates the distribution of minor incidents and assistance to drivers by lane blockage where almost 27,000 (or 87%) incidents caused mainly shoulder blockage. In contrast, most major incidents often resulted in multiple-lane blockage as shown in Figure 3.11. The overall distribution of incidents by lane blockage is illustrated in Figure 3.12.
Figure 3.12: Distribution of Incidents by Lane Blockage (the Entire Data Set)

The distribution of lane blockages for each of major roads is illustrated in Figures 3.13 through 3.16. It is evident that a very large number of incidents occurred only on shoulder lanes. For instance, shoulder lane blockage constituted about 78 percent of incidents on I-495/95, 85 percent for I-695, and about 71 percent on I-95. Most of such shoulder-lane incidents were related to some types of driver assistance such as flat tire, minor mechanical problems or running out of gas.

Figure 3.13: Distribution of Lane Blockages by Road in the Year 2000 – Driver Assistance (Short Forms)
Figure 3.14: Distribution of Lane Blockages by Road in the Year 2000 – Major Incident (Long Forms)

Figures 3.15 and 3.16 presents a comparison of such results for the year 2000 and year 1999 for major roads in the Baltimore and Washington Metropolitan areas.
Figure 3.15: Distribution of Lane Blockages by Major Freeways in the Washington Region

Figure 3.16: Distribution of Lane Blockages by Major Highways in the Baltimore Region
The analysis of lane blockages naturally leads to the computation of incident duration distribution. Figure 3.17 thus illustrates the distribution of lane blockages and their average duration on each major freeway. The number in each parenthesis denotes the percentage of data available from each category of incidents for computing its average incident duration. For instance, among all one-lane blockage incidents on I-495/95 in the year 2000, CHART response units only recorded the incident duration over 36% of their total operations, compared to that of 47 percents recorded in the year 1999. Thus, it should be recognized that all reported statistics in Figure 3.17 may be subjected to some degree of sample bias.

Figure 3.17: Distribution of Lane Blockages and Duration by Road in the Year 2000

3.5 Distribution of Incidents by Blockage Duration

This section presents the distribution of incidents by lane-blockage duration on the network covered by CHART. As shown on Figure 3.18, most minor incidents did not block traffic for more than half an hour. For instance, the number of incidents shorter than a half an hour for Washington D.C. region was about 92%, and 85% for the Baltimore area. Although those were mostly minor incidents, their impacts were quite significant as to cause traffic blockage and congestion during peak hours. The clearance of such blockages generally did not require special...
equipment and hence the resulting incident duration mainly depended upon the arrival of incident response units.

Note that there are a large number of short duration incidents, such as flat tires, on I-495/95 and I-270. Conceivably, without the timely response of TOC-3 patrol units most of such incidents would be prolonged over a much longer duration that may consequently cause more severe traffic congestion.

The year 2000 data has also indicated that I-270 frequently suffered from short duration incidents, with blockage duration less than half an hour. This may be due to a rapid growth in development along the I-270 corridor that has resulted in high traffic demand and severe congestion. However, among those four major freeway corridors, I-495/95 remains the one having the highest numbers of incidents.

![Figure 3.18: Distribution of Minor Incidents by Duration in the Year 2000](image)

With respect to major incidents, more than 50% of those responded by TOC-3 and TOC-4 lasted more than 30 minutes as shown in Figure 3.19. About 64% of reported incidents managed by SOC had blocked traffic for more than one hour in the year 2000.
Considering the commuting flow rate on I-495/95 and its incident frequency, one shall recognize the urgent need to implement an efficient incident management program. The high frequency of incidents on I-495/95 also confirms the general perception that incident-related traffic blockage is the primary contributor to the congestion on the Capital Beltway. In brief, it is clear that the highway network covered by CHART has been plagued by a high frequency of incidents, with a duration ranging from about 30 minutes to more than 3 hours. Those incidents were apparently one of the primary contributors to the traffic congestion in the entire region, especially on those major commuting highway corridors such as I-495, I-695, I-270 and I-95. Thus, there is an urgent need to continuously improve and upgrade the traffic management as well as incident response systems.

It should be noted that the number of incidents, as shown in Table 3-1, that plagued the traffic for more than 30 minutes seems to increase across all regions in the year 2000, compared to those in the year 1999. Special attention should be given to the type of incidents with duration between 30 minutes and 1 hour, which doubled its frequency in the year 2000 compared to the year 1999.
Considering the ever-increasing traffic demand and resulting incidents, it is likely that any investment for contending with such non-recurrent congestion should yield tremendous benefits to both the highway users and the quality of transportation systems for the entire region.
Chapter 4 DETECTION EFFICIENCY AND EFFECTIVENESS

4.1 Evaluation of Detection Efficiency and Effectiveness

The evaluation of incident detection efficiency and effectiveness shall, in general, cover the following critical issues:

- the overall incident detection rate and false alarm rate;
- the average duration from the starting time of an incident until the traffic control center has actually been informed;
- the ratio between the total number of detected incidents and those being responded immediately by the incident response team;
- the distribution of incident detection sources.

Since CHART has not implemented any automatic incident detection system, it naturally offers no information for evaluating the detection and false alarm rates.

The second issue, concerning how long it takes the traffic control center to receive an incident report from various sources after it has occurred, cannot be assessed in this study either, as the current incident management report, completed by operators in the traffic control center, does not contain such information. As such, the evaluation of detection efficiency and effectiveness can focus only on the latter two issues: incident response rate and distribution of detection sources.

4.2 Response Rate for Detected Incidents

The response rate discussed in this chapter is defined as the ratio between the total numbers of traffic incidents reported to the CHART control center and those managed by the CHART/MSHA incident response teams. According to the 1997 incident management record, CHART/MSHA had provided traffic management to 98 percent of reported incidents. This rate was up to 99% in the year 1999 and about 99.6% in the year 2000.

Similar to those in the previous year, existing incident reports available in CHART do not indicate the reasons for not responding to some incidents. It appears that most of such incidents either were incurred during very light traffic periods, or were not so severe as to block the traffic.
4.3 Distribution of Incident between Detection Sources

Despite the lack of automated incident detection systems, it is notable that CHART has maintained quite effective coordination with all other state and municipal agencies responsible for contending with traffic incidents and congestion. All CHART operation centers were able to take full advantage of various available sources for identifying incidents and taking necessary actions in a timely manner. With respect to the distribution of all detection sources, the statistics in Figure 4.1 clearly show that about 65 percent of incidents were detected by MSHA patrols, and an approximate of 17 percent were informed by the MSP in the year 2000 (59 and 20 percent in the year 1999).

![Distribution of Incident Detection Sources in the Year 2000 and 1999.](image)

Assuming that every incident can be detected immediately and reported to the traffic control center, it is still not uncommon to see that the time duration from the beginning of an incident to the arrival of incident management units could be excessively long due to some potential human-factors related delay in the entire response process. Thus, it would be desirable for CHART to have some reliable means such as having automated incident detection and dispatching system that can minimize any potential operational delay in response to a reported incident.
incident. All other information, including police reports, can certainly be used as supplemental sources to further confirm or better understand the incident condition.

Figure 4.2: Distribution of Detection Sources from TOC-3 in the Year of 2000 [1999]

Figure 4.3: Distribution of Detection Sources from TOC-4 in the Year of 2000 [1999]
Figure 4.2 illustrates the sources of detection for the Traffic Operation Center 3, and Figure 4.3 for TOC 4. Numbers in parenthesis show the data for the year 1999. As presented in those figures, it is evident that MSHA patrols in the year 2000 took the primary role for detecting and responding to reported highway incidents.
5.1 Analysis of Incident Response Efficiency

To analyze the efficiency of incident management operated by CHART/MSHA, it is essential to focus on the following aspects:

- **Travel Time** – or how long it takes an incident response unit to reach the reported incident site after the control center has been informed via various detection sources?

- **Response Travel Distance** - what is the average travel distance for incident response units to reach the identified incident site?

- **Clearance Time** - how long it takes the incident response team to clear various types of incidents?

- **Reduction in incident duration** - how many minutes of the incident blockage time has been reduced due to the operations of CHART/MSHA incident response units?

Having information on all above vital aspects will enable MSHA to have a clear picture of the efficiency at every stage of the incident management and operations. For instance, the information on the average travel time shall shed light to the effectiveness of interactions between the traffic control center and the offices responsible for dispatching incident response units.

If the duration between the arrival time of response units and the incident report time was found to be unexpectedly long, it should be an indication of having inadequate response units, or an operating process that may easily cause operators to cause delay in calling for the dispatching operations. The information on the first aspect, along with the data on the distribution of Travel Distance to incident sites, shall also enable MSHA to evaluate its routing strategies for emergency response units, and assess if the current equipment is sufficient to respond to the increasing number of incidents during peak periods. One may consider placing some available incident response units along highway segments, identified to have a high incident frequency, at different times of a day, so as to minimize the travel time to potential incident sites.

Since the current incident reports do not contain information on travel distance, the evaluation of management efficiency has focused mainly on the distribution of response times and incident duration. Note that the response time, as presented in Chapter 1, should be the time difference between the actual time the incident has occurred and the time the response vehicle
has arrived at the scene. Since it is difficult to know the actual time of the incident occurrence, the response time used in this study is based on the difference between the time the Response Center has received the call and the time the response unit has arrived at the site of the incident. The average response time for minor incidents and assistance to drivers was computed to be about 16 minutes in the year 2000 for TOC-3, TOC-4, as shown in Figure 5.1.

![Figure 5.1: Response Time for Minor Incidents & Driver Assistance](image)

For more severe incidents reported in the year 2000, the average Response Time from each response center in the year 2000 has been computed in this study and shown in Figure 5.2.

![Figure 5.2: Average Response Time for Major Incidents](image)
Average response time for all types of incidents for the year 2000 is given in Figure 5.3. It should be mentioned that TOC-4 offered only 4 months of incident data in the year 1999 for analysis, resulting in an obviously biased estimate of response time. Thus, the comparison of response performance between the year of 1999 and 2000 should be based on the statistics without the TOC-4.

### 5.2 Reduction in Incident Duration

Aside from evaluation of the entire incident management process, one of the major performance indicators is the reduction in average incident duration due to the operations of CHART/MSHA response units. Theoretically, to have a reliable estimate for such an indicator one should perform a typical before-and-after analysis. However, most incident management related data prior to the actual operations of CHART are practically unavailable for any meaningful analysis. Thus, the alternative is to compute the average incident clearance time in the year 2000 with and without the assistance from CHART/MSHA response units as it was done in previous evaluation.

Since the CHART incident management team has responded to most incidents in the year 2000, the data associated with non-responded incidents for performance comparison are quite limited. As shown in Table 5.1, the average duration to clear an incident with and without the
assistance of CHART was about 33 minutes versus 77 minutes. It is impossible to perform the comparison of incident duration for every CHART operating center due to the very small amount of incidents non-responded by CHART.

Based on the results shown in Table 5.1, it is seemingly that with the assistance of CHART/MSHA response units, the clearance duration has been substantially reduced for all types of incidents, ranging from one-lane to multiple-lane closures. On average, CHART has contributed to about 57 percent reduction in the incident blockage duration in the year 2000, at exactly the same level of reduction as in the year 1999.

However for the most often type of 2 lanes blockages, the incident duration time was reduced from 52 minutes in the year 1999 to about 36 minutes in the year 2000, about 30% reduction in incident duration. For one and three lanes blockages, the average incident had a reduction up to 31 percent and 26 percent, respectively. Overall, this reduction in incident recovery time has certainly contributed to significant savings on travel time, fuel consumption as well as other related social impact costs due to non-recurrent congestion.

<table>
<thead>
<tr>
<th>Blockage</th>
<th>With SHA Patrol</th>
<th>Without SHA Patrol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Duration (min)</td>
</tr>
<tr>
<td>1 lane</td>
<td>1,087</td>
<td>20.17 (29)</td>
</tr>
<tr>
<td>2 lanes</td>
<td>1,147</td>
<td>35.53 (52)</td>
</tr>
<tr>
<td>3 lanes</td>
<td>331</td>
<td>39.46 (54)</td>
</tr>
<tr>
<td>&gt;=4 lanes</td>
<td>245</td>
<td>69.60 (67)</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>245</td>
<td>33.02 (42)</td>
</tr>
<tr>
<td>Total Samples</td>
<td>2,810</td>
<td>122</td>
</tr>
</tbody>
</table>

* The number in each parenthesis shows the data in the year 1999.
In review of the above statistics, it is noticeable that the average incident duration for those without assistance from CHART/SHA, has also been reduced significantly across all types of lane-blockage incidents. For instance, the average non-responded incident duration was 77 minutes in the year 2000, much shorter than the average of 93 minutes in the year 1999. This seems to reflect the fact that efficient response to incidents so as to minimize non-recurrent congestion and its impacts on the driving populations has received increasing attention among all responsible agencies.
Chapter 6 BENEFITS FROM THE INCIDENT MANAGEMENT BY CHART

6.1 Estimation of Benefits

Despite the well perceived benefits from an efficient incident management system, most state highway agencies, including MSHA, are facing the pressing need to justify their system investment and operating costs, especially in view of the diminishing resources and the increasing demand for infrastructure renovation. Thus, quantifying the benefits from the operations of incident management system is one of the essential tasks for evaluation of CHART.

Due to the concern of ensuring the quality of analysis under the data limitations as well as resource constraints, the benefit assessment of CHART has always been focused only on those either directly measurable or quantifiable from the incident reports. Such direct benefits, including to both roadway users and to the entire community, are classified as follows:

- Assistance to drivers;
- Reduction in secondary incidents;
- Reduction in driver delay time;
- Reduction in vehicle operating hours;
- Reduction in fuel consumption and
- Reduction in emissions.

Some other indirect impacts, such as improving the air quality, vitalizing local economy, and increasing network mobility, are not included in the evaluation report.

6.2 Assistance to Drivers

Among all 34,891 incident reports available in the CHART database, it has been found that there were a total of 19,257 incidents associated with requests from drivers for some types of assistance such as flat tire, shortage of gas, or some mechanical problems (Figure 6.1). This number is lower than a total of 22,154 assistance requests from drivers in the year 1999. Note that the introduction of new format in the incident report form has resulted in a substantial reduction (i.e., from 11,551 in the year 1999 to 4,753 in the year 2000) of unknown type records in the incident database. Out of 14,500 assistance requests from drivers, a total of 4,200 were related to ‘out of gas’ and ‘flat tire’ of vehicles.
Figure 6.1: Nature of Driver Assistance Requests in the Year of 2000 and 1999

Note that according to CHART operators, its response teams actually responded to many more assistance requests from drivers than those documented 19,257 incidents. However, most of those unreported driver assists did not need major efforts or equipment from the response team, and thus were not recorded.

Conceivably, the prompt response of CHART incident management units to such requests not only has been greatly appreciated by the general public, but also has contributed directly to minimizing the potential rubbernecking effects on the traffic, especially during peak hours, that could result in excessive delay. Thus, despite the difficulty in precisely quantifying the impacts of such assistance, it shall undoubtedly be counted as one of the major direct benefits.

The overall distribution of assistance requests from drivers (code named 1046) by nature in the year of 1999 and 2000 can be seen from Figure 6.1. Among those, the distribution managed by TOC-3 and TOC-4 is illustrated in Figures 6.2 and 6.3, respectively.

It should be noted that a significant number of assistance requests, as shown in Figure 6.2, was not documented clearly, and thus was classified into the category of either “unknown” or ‘Other’ types. This certainly reflects the need to further revise the incident record form.
Figure 6.2: Nature of Driver Assistance Requests in the Year of 2000 and 1999-TOC-3

Figure 6.3: Nature of Driver Assistance Requests in the Year of 2000 and 1999-TOC-4
6.3 Potential Reduction in Secondary Incidents

It has been well recognized that one major accident may incur a number of relatively minor secondary incidents due to a sudden change in the traffic condition, such as the rapid spreading of queue length and a dramatic drop in the traffic flow speed. The likelihood of having such incidents increases consistently with the incident duration and the congestion level. Thus, an efficient recovery of incident blockage not only may directly benefit drivers in the traffic queue, but also may reduce potential incidents incurred by incoming vehicles that may further deteriorate the traffic condition.

Note that there is no universal definition for “secondary incidents” in the transportation literature, unless the nature of incidents can be known directly from the field data. Grounded on the experience from our previous work, this study has adopted the following definition for secondary incidents that can better account for incidents caused by rubbernecking effects in the opposite traffic direction:

- incidents incurred within two hours from the onset of a primary incident and also within two miles downstream of the primary incident location; or
- incidents incurred in the opposite direction that are within half hour from the onset of a primary incident, and lie within half mile either downstream or upstream of the primary incident location.

For convenience of comparison, Figure 6.4, however, presents the distribution of secondary incidents under different definitions based on the year 2000 Accident Data Base provided by Maryland State Police Department.
Notably, under the selected definition, there were 956 secondary incidents occurred in the year of 2000. As the frequency of secondary incidents reveals a clear positive correlation with the primary incident duration, it is conceivable that without implementing the incident management program, the resulting number of secondary incidents would be significantly higher.

For convenience but without loss of the generality, one may assume such a correlation as linear in nature, and estimate the potential reduction in the total secondary incidents due to CHART/MSHA response units as follows:

- Reported number of secondary incidents: 956
- The estimated number of secondary incidents without CHART/MSHA response units (that has resulted in a 57% reduction on the average incident duration): 
  \[ \frac{956}{1-0.57} = 2,223 \]
- The number of potentially reduced secondary incidents due to the operations of CHART:
  \[ 2,223 - 956 = 1,267 \]
Note that each of those 1,267 secondary incidents, if actually occurs, may further prolong its primary incident duration and result in additional loss of travel time, fuel consumption, and congestion on surface streets. Such impacts and accompanying benefits are not computed in this report due to data limitations, but should be investigated in the future study.

6.4 Estimated Benefits due to Efficient Removals of Stationary Vehicles from Travel Lines

As have been commonly observed around incident sites, many drivers are forced to perform undesirable lane-changing maneuvers due to lane-blockages. Considering the fact that a large number of traffic accidents has been incurred due to improper lane changes, it is likely that a prolonged incident operation may result in some accidents. Thus, the operation of CHART/MSHA that has contributed to a substantial reduction in incident impact duration and efficient removals of stationary vehicles in travel lanes may directly prevent some potential lane-changing related accidents around incident sites. This study has attempted to explore such a benefit from CHART/MSHA with limited available data. The research scope as well as procedures are summarized below:

Scope of Analysis:

Only those incidents incurred on I-495/95, I-95, I-270, I-695, I-70, and I-83 during peak periods are included in the analysis.

Procedures:

- Performing field observations of the number of lane changes, flow rate, speed, and density on a segment I-495/I-95 over both peak and off-peak period;
- Developing a statistical relation between the number of non-mandatory lane changes and traffic conditions;
- Computing the ratio between the total number of lane-blockage related incidents (see Figures 3.15 and 3.16) and the total number of lane changes over the given freeway segment estimated with developed statistical models. For instance, the analysis result indicates that about 5,330 non-mandatory lane changes on I-495/95 will cause one accident.
• Computing the number of lane-changes for those incidents resulting in lane blockages, based on the incident duration, number of lanes being blocked, and the approximate traffic volume on those blocked lanes.

• Estimating the potentially reduced accidents for each freeway, based on the estimated number of lane changes for each incident and the ratio between accident and the number of undesirable lane-changing maneuvers.

A graphical illustration of the estimation procedures is described in Figure 6-5, and the estimated results for those target freeways are reported in Table 6.1. Note that this estimation has been focused only on the peak period as the relation between lane-changing maneuvers and accidents is found to be statistically uncorrelated in our limited data set.

Table 6.1: Reduction of Potentially Incidents due to CHART Operations

<table>
<thead>
<tr>
<th>Road Name</th>
<th>I-495/I-95</th>
<th>I-95</th>
<th>I-270</th>
<th>I-695</th>
<th>I-70</th>
<th>I-83</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mileage</td>
<td>41</td>
<td>63</td>
<td>32</td>
<td>44</td>
<td>13</td>
<td>34</td>
</tr>
<tr>
<td>Number of potentially incidents reduced</td>
<td>297</td>
<td>12</td>
<td>14</td>
<td>47</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>
Figure 6.5: A Flow Chart of the Procedures for Approximating the Potentially Reduced Lane-changing Related Accidents due to Operations of CHART
6.5 Direct Benefits to Highway Users

As reported in previous CHART evaluation studies, the computation of additional delays and fuel consumption due to CHART operations is performed with the following models:

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

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

Where

- \( \Delta \text{Delay} = \) Excessive delay due to incidents
- \( \Delta \text{Fuel} = \) Additional fuel consumption due to incidents
- \( TNL = \) Total number of lanes
- \( NLB = \) Number of lanes blocked
- \( V = \) Traffic volume
- \( ID = \) Incident duration
- \( \varepsilon_1 \) and \( \varepsilon_2 \) - are random terms for modeling errors.

Prior to the use of above equations, all roads covered by CHART were divided into homogenous segments based on geometry (number of lanes) and volume (peak-hour). The overall computation results indicate that all incidents occurred in the year of 2000 may result in a total of 66.59 million veh-hrs delays if without CHART/MSHA operations. In contrast, due to efficient response and management of CHART, the total vehicle delay has been reduced to 42.35 million hours, about 24.24 million hours less than that without the assistance of CHART/MSHA.
Reduction in Delay due to CHART

Numbers in parentheses show 1999 result.

- Reduction in delay due to CHART = 24.24 (23.36) million veh-hrs
- Total delay if without CHART: 66.59
- Total delay with CHART: 42.35

* The number in each parenthesis represents the data in the year 1999.

**Figure 6.7: Reduction in Delays due to CHART/MSHA Operations**

In addition to the above total delay reduction, this study has further computed such a benefit due to CHART/MSHA operations to both Baltimore and Washington regions, and presented in Tables 6.2 and 6.3.

**Table 6.2: Direct Benefits to Road Users in the Washington Region**

<table>
<thead>
<tr>
<th>Segment</th>
<th>No. Lane Blockages</th>
<th>Delay Reduction due to CHART operations, veh-hours</th>
<th>Fuel Reduction due to CHART operations, gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-95/495</td>
<td>1,560</td>
<td>11,532,000</td>
<td>154,000</td>
</tr>
<tr>
<td>I-270</td>
<td>243</td>
<td>1,149,000</td>
<td>16,500</td>
</tr>
<tr>
<td>US-50</td>
<td>122</td>
<td>1,077,000</td>
<td>13,000</td>
</tr>
<tr>
<td>MD-295</td>
<td>79</td>
<td>1,146,000</td>
<td>12,400</td>
</tr>
<tr>
<td>US-1</td>
<td>9</td>
<td>3,000</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>2,012</td>
<td>14,907,000</td>
<td>196,000</td>
</tr>
</tbody>
</table>
Table 6.3: Direct Benefits to Road Users in the Baltimore Region

<table>
<thead>
<tr>
<th>Segment</th>
<th>No. Lane Blockages</th>
<th>Delay Reduction due to CHART operations, veh-hours</th>
<th>Fuel Reduction due to CHART operations, gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-95</td>
<td>342</td>
<td>2,686,000</td>
<td>35,000</td>
</tr>
<tr>
<td>I-695</td>
<td>772</td>
<td>4,666,000</td>
<td>65,000</td>
</tr>
<tr>
<td>I-70</td>
<td>67</td>
<td>249,000</td>
<td>4,000</td>
</tr>
<tr>
<td>I-83</td>
<td>174</td>
<td>849,000</td>
<td>12,000</td>
</tr>
<tr>
<td>MD-295</td>
<td>90</td>
<td>173,000</td>
<td>3,000</td>
</tr>
<tr>
<td>US-1</td>
<td>16</td>
<td>66,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Total</td>
<td>1,460</td>
<td>8,689,000</td>
<td>120,000</td>
</tr>
</tbody>
</table>

Overall, the total benefits in term of reduction in total delay time and fuel consumption based on the same parameters used in 1997 for convenience of comparison can be summarized as follows:

- Total delay savings: 24.24 million hours = $347.6 million ($14.34/hour)
- Total fuel consumption reduction: 4.1 million gallons = $4.1 million ($1/gal.)

6.6 Emission Reduction Benefits

The estimated reductions in vehicle emissions were based on the following parameters provided by MDOT (which have been used for air pollution evaluation in both Baltimore and Washington D.C. areas) and the total delay reduction of 24.24 million vehicle hours due to CHART/MSHA operations:

- **HC**: 316.9 tons (13.073 grams per hour of delay);
- **CO**: 3559 tons (146.831 grams per hour of delay);
- **NO**: 151.8 tons (6.261 grams per hour of delay);

Using the cost parameter of $6,700/ton for HC, $6,360/ton for CO and $12,875/ton for NO (Patrick, 1998), the above reduction in emission has resulted in a total saving of **$26.7 million**. Thus, the operation of CHART/MSHA in the year of 2000 has generated a total benefit of **$378.4 million** ($347.6M + $4.1M + 26.7 M), slightly higher than the benefit of $346 million in the year of 1999.
Further analysis of the savings in daily emission costs due to CHART/MSHA operations has also been conducted for both Baltimore and Washington regions and presented in the following table. Note that the daily benefits were computed with the total delay reduction during the operations of week days as about 98 percent of incidents reported in the year of 2000 occurred during week days.

<table>
<thead>
<tr>
<th>Table 6.4: Daily Benefits in Emissions Reduction due to CHART Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Total by CHART during weekdays</td>
</tr>
<tr>
<td>Washington Region</td>
</tr>
<tr>
<td>Baltimore Region</td>
</tr>
</tbody>
</table>
Chapter 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Grounded on our previous research results and experience, this study has performed a rigorous evaluation of CHART’s performance in the year of 2000, and computed the resulting benefits due to its operations under the constraints of data availability and quality. In response to the availability of a relatively rich data set, the study has expanded its research scope to include a comprehensive data quality evaluation, intending to provide the basis for further data recording improvement. In addition to what has been explored in the study is the estimate of a potential reduction in lane-changing related accidents at lane-blockage incident sites due to the operations of CHART, as a longer incident duration will force more drivers to perform unsafe and undesirable lane changes that are likely to result in crashes.

Overall, CHART has made a significant progress in both the data recording and quality improvement, although much remains to be improved so as to reliably account for all associated benefits. CHART’s efficiency in responding to and managing incidents has also been improved substantially. For instance, the average response time has been reduced from 16.75 minutes in the year of 1999 to 15 minutes in the year of 2000, and the average incident duration has also been from 42 minutes to 33 minutes over the same period. The total benefits due to CHART operations have also increased from $346 million in the year 1999 to $380 million in the year of 2000.

In summary, the operations of CHART/MSHA in the year of 2000 have yielded significant benefits on the following areas:

- Assistance to drivers’ service requests;
- Reduction in the trip delay time;
- Reduction in the fuel consumption cost;
- Reduction in accidents due to stationary vehicles or large debris in the travel lanes;
- Potential reduction in secondary incidents; and
- Reduction in emissions;
Most indirect benefits could be estimated provided that some essential data regarding traffic conditions before-and-after incidents were collected during each operation. Such benefits include:

- All impacts associated with an incurred secondary incident;
- Potential impacts on neighboring surface streets during incidents; and
- Reduction in the overall stress to drivers in major commuting corridors.

The aforementioned benefits, along with the ever-increasing congestion and incidents, certainly justify the need to best manage and continuously upgrade the current incident response program. However, it should be noted that “an efficient incident response” alone cannot effectively reduce the number of primary highway incidents. Considering the current volume level in major commuting highways, it is certainly true that commuters, even under an efficient incident response system, remain likely to face a long delay for any encountered incident. Thus, taking “preventive measures” to minimize the likelihood of having incidents should, at least, be viewed as vital as implementing an incident management program. An in-depth analysis of the incident nature and their spatial distribution should offer some insightful information for developing safety-improvement related measures.

7.2 Recommendations and Further Development

The primary recommendations based on the performance of CHART in the year 2000 are summarized below:

Continuing the efforts on training operators to effectively record all essential operations related data. -- As reported in Chapter-2, data quality evaluation, many of those incident reports in the year 2000 were found to have a large number of either missing or incomplete items. Some of those missing data (e.g., incident blockage duration) are often so critical in the benefit computation.

Automating the current incident report procedures that can offer both the assistance to and the flexibility for operators to record all vital information that are essential for improving the operations efficiency and justifying the resulting benefits. -- Although the overall data quality has been improved significantly in the year 2000, many vital information items in the incident
reports, such as assistance to driver requests, were either undocumented or classified into “others”.

Conducting the current evaluation and benefit analysis on a quarterly basis so that all performance related results can be fed back to CHART in a timely manner to continuously improve its operations. -- All timely reported benefits may also be useful for CHART to best allocate the available resources and sustain the support from both the general public and state policymakers.

Developing an integrated performance database that consists not only of incident reports but also all data, such as traffic volume, needed for direct benefit computation or estimation of safety related contribution, including potentially reduction in secondary incidents and lane-changing related accidents due to a quick removal of stationary vehicles or some debris on highway travel lanes.

Improving the use of freeway service patrols and dynamically assigning their locations based on both the spatial distribution of incidents along freeway segments and the probability of having incidents at different times of a day so that the average response time can be reduced as expected.

Integrating the incident performance evaluation module with the CHART’s operations and information management system so that the evaluation module not only can generate the up-to-date CHART performance report as needed, but also an integrated component of the entire operations.
References


13. Incident reports for 1997 from Statewide Operation Center, Traffic Operation Center 3 and 4, State Highway Administration, Maryland.


20. Department of Business and Economic Development. Maryland Wages by Occupation, Maryland
