Year 2024

July 2025

Performance Evaluation and Benefit Analysis For CHART

– Coordinated Highways Action Response Team –

Traffic Safety and Operations Lab

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Environmental Engineering

The University of Maryland, College Park

Office of Transportation

Mobility and Operations

State Highway Administration

Performance Evaluation of CHART

The Real-Time Incident Management System (Year 2024)

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EXECUTIVE SUMMARY

Objectives

This report presents the performance evaluation study of the Coordinated Highways Action Response Team (CHART) for the Year 2024, including its operational efficiency and resulting benefits. The research team at the Civil Engineering Department of the University of Maryland, College Park (UM), has conducted the annual CHART performance analysis over the past twenty-seven years for the State Highway Administration (SHA).

As with previous studies, the focus of this task was to evaluate the effectiveness of CHART's ability to detect and manage incidents on major freeways and highways. Assessing the benefits resulting from incident management was equally essential. In addition, this annual report has extended the analysis of incident duration distributions on major highways for a better understanding of the incident characteristics and management.

The study consisted of two phases. Phase 1 focuses on defining objectives, identifying the available data, and developing the methodology. The core of the second phase involved assessing the efficiency of the incident management program and estimating the resulting benefits using the 2024 CHART incident operations data. As some information essential for efficiency and benefit assessment was not available in the CHART-II database, this study presents only those evaluation results that can be directly computed from the incident management data or derived from statistical methods.

Available Data for Analysis

Upon a request made by SHA, COSMIS began evaluating CHART operations' performance in 1996. During the initial evaluation, the 1994 incident management data from the Traffic Operations Center (TOC) were reviewed but for various reasons were not used. Thus, the conclusions drawn were based mostly on information either from other states or from nationwide averaged data published by the Federal Highway Administration.

To better the evaluation quality and because the Statewide Operations Center (SOC) has been opened in August of 1995, those associated with the evaluation study concluded that the analysis should be based on actual performance data from the CHART program. Hence, in 1996, the UM (Chang and Point-Du- Jour, 1998) was contracted to work jointly with SHA staff to collect, and subsequently research items to analyze incident management data.

This original study and evaluation analysis inevitably faced the difficulty of having insufficient information for analysis, since this was the first time CHART had to collect all previous performance records for a scrupulous evaluation.

The 1997 CHART performance evaluation had the advantage of having relatively substantial information. The collected information comprised incident management records from the Statewide Operations Center (SOC), TOC-3 (positioned in the proximity of the Capital Beltway), and TOC-4 (sited near the Baltimore Beltway) over the entire year, as well as 1997 Accident Report Data from the Maryland State Police (MSP) for secondary incident analysis.

Unlike previous studies, the quality and quantity of data available for performance evaluation have increased considerably since 1999. These results from CHART reflect the need to keep an extensive operational record to justify its costs and to evaluate the benefits of the emergency response operations. Due to CHART's efficient data collection, the records of lane-closure-related incidents increased from 2,567 in 1997 to 41,261 in 2024.

Table E.1 shows the total number of emergency response operations assiduously documented from 2020 to 2024.

Table E.1 Summary of the Total Number of Emergency Responses from 2020 to 2024

	2020	2021	2022	2023	2024	Δ (2024-2023)
Incidents only	34,590 (26,702)	38,275 (29,546)	38,957 (28,972)	40,073 (29,864)	41,261 (30,811)	2.96% (+3.17%)
Total [1]	70,115 (60,665)	76,722 (65,839)	75,841 (63,474)	82,987 (70,346)	78,179 (65,710)	-5.79% (-6.59%)

Note: 1. Total includes incidents and disabled vehicles (i.e., assists to drivers).
2. Number in the parenthesis shows the incidents or assists responded by CHART.

The main findings from Table E.1 are listed below:

- The total number of recorded incidents in 2024 increased by 2.96% compared to 2023.
- The number of incidents responded by CHART in 2024 increased by 3.17% compared to 2023.
- The numbers of both total emergency responses (including disabled vehicles) and those responded by CHART significantly decrease in 2024.

Evolution of the CHART Evaluation Work

CHART has consistently worked to improve its data recording for both major and minor incidents over the past two decades, which accounts for the substantial improvements in data quality and quantity. The evaluation work has also been advanced by the improved availability of data. It has also become imperative to assess the quality of available data and to use only reliable data in the benefit analysis. Thus, from 1999, the performance evaluation reports have included data quality analysis. This aims to ensure continued advancement in the quality of incident-related data so as to reliably estimate all potential benefits of CHART operations.

From February 2001, all incidents requesting emergency assistance have been recorded in the CHART-II information system, regardless of CHART's involvement or not. This has significantly improved the available data for analysis. In the current CHART database system, most incident-related data can be generated directly for computer processing, except that incident-location-related information remains documented in a text format that cannot be processed automatically with a data analysis program.

Distribution of Incidents/Disabled Vehicles

The evaluation methodology was created to use all available data sets that are of acceptable quality. An analysis of incident characteristics by incident duration and number of blocked lanes was initially conducted.

As shown in Table E.2, the 2024 incident records indicate that there were a total of 2,784 incidents resulting in one-lane blockage, 9,895 incidents causing two-lane closures, and 6,011 incidents blocking three or more lanes. In addition, either disabled vehicles or minor incidents caused a total of 43,842 shoulder blockages. A comparison of the lane-blockage incidents and disabled vehicles data over the past five years is summarized in Table E.2:

Table E.2 List[1] of Incidents/Disabled Vehicles by Lane Blockage Type

	2020	2021	2022	2023	2024	Δ (2023-2024)
Shoulder[2]	41,409	45,258	44,933	45,044	43,842	-2.67%
1 lane	3,221	3,290	3,320	3,100	2,784	-10.19%
2 lanes[3]	8,205	9,328	9,238	9,399	9,895	5.28%
3 lanes[3]	2,780	3,062	3,235	3,392	3,423	0.91%
≥ 4 lanes[3]	2,331	2,472	2,457	2,451	2,588	5.59%

**Note: 1. This analysis is based only on the samples with complete information for the lane blockage status.*
2. Shoulder Lane Blockages include events that have disabled vehicles (i.e., assists to drivers)
3. A shoulder lane blockage is counted as one lane blockage (e.g., 2-lane blockage can either be two travel lanes or one travel lane and one shoulder blockage.)

Most of those incidents/disabled vehicles were distributed along six major commuting corridors: I-495/95, which experienced a total of 7,207 incidents/disabled vehicles in 2024; I-695, I-95, US-50, I/MD-295, and I-270 with 7,225, 23,625, 6,236, 2,288, and 3,324 incidents/disabled vehicles, respectively. CHART managed an average of 65 emergency requests per day on I-95 alone, and 20, 20, 17, 6, and 9 responses per day for I-495/95, I-695, US-50, I/MD-295, and I-270, respectively. The distribution of incidents/disabled vehicles on those major commuting corridors between 2020 and 2024 is shown in Table E.3:

Table E.3 Summary* of Incidents/Disabled vehicles Distribution on Major Freeway Corridors

	2020	2021	2022	2023	2024	Δ (2024 - 2023)
I-495/95	10,339	12,068	10,371	9,768	7,207	-26.22%
I-695	8,025	8,585	9,529	8,534	7,225	-15.34%
I-95	12,937	12,838	14,052	19,885	23,625	+18.81%
US-50	6,492	7,807	6,272	7,449	6,236	-16.28%
I/MD-295	2,694	3,120	2,738	2,756	2,288	-16.98%
I-270	4,058	4,484	4,200	3,994	3,324	-16.78%

** This analysis is based on incidents and disabled vehicles having the information of their event locations recorded in the database.*

Freeway segments experiencing most incidents and disabled vehicle assists during the AM and PM hours in 2024 are shown in Table E.4. The highest frequency of incidents occurred on the I-95 northbound segment between Exits 67 and 74 in both AM and PM peaks, respectively. The southbound segment on I-95 between Exits 67 and 74 ranked the first with the respect to the number of disabled vehicle requests in 2024 in both AM and PM peak hours, respectively.

Table E.4 Top 10 Freeway Segments with the Most Incidents/Disabled Vehicles in 2024

	Incidents				Disabled vehicles			
	AM Peak		PM Peak		AM Peak		PM Peak	
1	I-95 N	Exit 67&74	I-95 N	Exit 67&74	I-95 S	Exit 67&74	I-95 S	Exit 67&74
2	I-95 S	Exit 56&57	I-95 N	Exit 55&56	I-95 N	Exit 67&74	I-95 N	Exit 67&74
3	I-95 S	Exit 67&74	I-95 S	Exit 67&74	I-95 N	Exit 61&64	I-95 N	Exit 61&64
4	I-895 S	Exit 8&12	I-895 N	Exit 12&14	I-95 N	Exit 64&67	I-95 N	Exit 77&80
5	I-95 S	Exit 58&59	I-95 N	Exit 50&52	I-95 S	Exit 62&64	I-95 N	Exit 64&67
6	I-495 OL	Exit 28&29	I-95 N	Exit 74&77	I-95 N	Exit 77&80	I-95 S	Exit 62&64
7	I-95 S	Exit 50&52	I-895 S	Exit 8&12	I-95 S	Exit 50&52	I-95 S	Exit 64&67
8	I-695 OL	Exit 16&18	I-695 IL	Exit 11&12	I-95 S	Exit 80&85	I-95 S	Exit 77&80
9	I-95 S	Exit 64&67	I-95 N	Exit 51&52	I-95 N	Exit 80&85	I-95 N	Exit 67&74
10	I-95 S	Exit 93&100	I-895 N	Exit 9&10	I-95 N	Exit 74&77	I-95 S	Exit 100&109

** This analysis is based on incidents and disabled vehicles having the information of their event locations recorded in the database*

It should be mentioned that most incidents/disabled vehicles on major freeways did not block traffic for more than one hour. For instance, about 72 percent of incidents/disabled vehicles had durations shorter than 30 minutes in 2024. This observation can be attributed to the nature of the incidents and, more probably, to the efficient response of CHART. The distributions of incidents/disabled vehicle duration from 2020 to 2024 are summarized in Table E.5:

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Table E.5 Distribution* of Incidents/Disabled Vehicle Duration from 2020 to 2024

Duration (Hrs)	2020	2021	2022	2023	2024
D < 0.5	73%	72%	72%	74%	72%
0.5 ≤ D < 1	15%	15%	16%	15%	15%
1 ≤ D < 2	7%	8%	8%	7%	8%
2 ≤ D	5%	5%	5%	4%	5%

** This analysis is based on incidents and disabled vehicles (i.e., assists to drivers) which have complete information for the event duration.*

In brief, it is apparent that the highway networks served by CHART are still plagued by a high frequency of incidents with durations ranging from 10 to over 120 minutes. Those incidents were the primary contributors to traffic congestion in the entire region, especially on the major commuting highway corridors, such as I-95, I-895, I-495/95, and I-695.

Efficiency of Operations

Detection, response, and traffic recovery are the three vital performance indicators associated with an incident management program. Unfortunately, data needed for the detection and response time analysis are not yet available under the CHART data system. SHA patrols and MSP remain the main sources of incident detection and response.

The average response time is defined as the average time from receiving an emergency request to the arrival of an emergency response unit. Table E.6 shows the average response times of 13.45, 15.20, 11.67, 14.99, and 10.05 minutes for TOC-3, TOC-4, TOC-7, SOC, and AOC, respectively, in 2024. Note that TOC-3 relocated back to their center on July 24th, 2024. All centers except TOC-3 experienced a slight increase in response time in 2024. Note that incidents/disabled vehicles included in this analysis were responded by various units, including CHART and non-CHART agencies.

Table E.6 Evolution of Response Times[1,2,3] by Center from 2020 to 2024

Response Time (mins)	2020	2021	2022	2023	2024		
					During OH[4]	After OH	Overall
TOC-3[6]	12.17	12.64	4.65	19.6	*13.47 (1,485)[5]*	*10.09 (6)*	*13.45 (1,491)*
TOC-4	12.98	14.03	14.51	14.88	*15.20 (4,248)*	*13.75 (22)*	*15.20 (4,270)*
TOC-7	11.42	11.83	11.78	11.42	*11.79 (2,810)*	*11.28 (850)*	*11.67 (3,660)*
SOC	14.32	14.67	14.79	14.40	*14.99 (9,119)*	*N/A*	*14.99 (9,119)*
AOC	9.03	9.45	10.04	9.95	*10.05 (10,566)*	*N/A*	*10.05 (10,566)*
OTHER	2.53	8.58	13.09	6.51	*N/A*	*8.46 (31)*	*8.46 (31)*
Weighted Average	**11.64**	**12.25**	**12.88**	**12.74**	***12.77 (28,228)***	***11.24 (909)***	***12.73 (29,137)***

** Note: 1. This analysis is based on the data of incidents and disabled vehicles (i.e., assists to drivers) which have indicated the responsible operation center and response times.*

2. This analysis includes those data that have response times between 1 minute and 60 minutes.

3. Events included in this analysis were responded to by various units, including CHART, fire boards, state/local polices, private towing companies, etc.

4. OH stands for Operational Hours: TOC-7 operates 5 a.m. – 9 p.m. Monday through Friday. TOC-3 and TOC-4 began operating seven days a week (5 a.m. - 9 p.m.) as of August 30th, 2017. SOC and AOC operate on a 24 hour/seven-days-a-week basis.

5. The number in each parenthesis indicates the numbers of available samples with acceptable quality for analysis.

6. As of January 2022, TOC-3 had been relocated to SOC due to staff related issues. TOC 3 relocated back to their center on July 24th, 2024.

Table E.7 presents that incidents are likely to be responded more promptly than disabled vehicles, especially during operational hours.

Table E.7 Comparisons of CHART Response Performance[1,2,3] during and after Operational Hours

Response Time (mins)	Operational Hours[4]		Non-operational Hours		Total		
	Incident	Disabled Vehicle	Incident	Disabled Vehicle	Incident	Disabled Vehicle	Sub-total
TOC-3[6]	12.05 (1220)[5]	19.97 (265)	7.89 (5)	21.13 (1)	12.04 (1225)	19.97 (266)	13.45 (1491)
TOC-4	13.66 (3187)	19.85 (1059)	14.99 (19)	9.33 (4)	13.67 (3206)	19.81 (1063)	15.2 (4269)
TOC-7	11.32 (2299)	13.94 (511)	11.2 (682)	14 (172)	11.29 (2981)	13.96 (683)	11.79 (3664)
SOC	12.96 (6513)	20.08 (2604)	N/A	N/A	12.96 (6513)	20.08 (2604)	14.99 (9117)
AOC	9.3 (7169)	11.42 (3351)	N/A	N/A	9.3 (7169)	11.42 (3351)	9.98 (10520)
OTHER	N/A	N/A	8.17 (24)	10.24 (7)	8.17 (24)	10.24 (7)	8.64 (31)
Weighted Average	**11.54 (20388)**	**15.92 (7790)**	**11.18 (730)**	**13.8 (184)**	**11.53 (21118)**	**15.87 (7974)**	**12.72 (29092)**

** Note: 1. This analysis is based on the dataset of incidents and disabled vehicles (assistance to drivers) which have indicated responsible operation center and response times.*

2. This analysis includes those sample data which have CHART response times between 1 minute and 60 minutes.

3. Events included in this analysis were responded by CHART.

4. Operational Hours: TOC-7 operate 5 a.m. – 9 p.m. Monday through Friday. TOC-3 and TOC-4 began operating seven days a week (5 a.m. - 9 p.m.) as of August 30th, 2017. SOC and AOC operate on a 24 hour/seven-days-a-week basis.

5. The number in each parenthesis indicates the numbers of available samples with acceptable quality for analysis.

6. TOC 3 relocated back to their center on July 24th, 2024.

Also, the 2024 data show that CHART's response operations are more efficient when incidents are more severe and cause lane blockages. In general, more severe incidents, especially involving fatalities or heavy vehicles, demand longer clearance times.

Analysis of Incident Durations

To better understand the contributions of the incident management program, the study compared the average duration of incidents to which CHART responded and those managed by other agencies. For example, the difference on the average response times for one-lane-blockage incidents between with and without CHART involvement is about 8.99 minutes.

The duration of incidents managed by CHART response units averaged 26.01 minutes, shorter than the average duration of 34.34 minutes for those incidents by other agencies. On average, CHART operations in Year 2024 reduced the average incident duration by about 24.3 percent.

Performance improvement of CHART operations from years 2020 to 2024 is summarized in Table E.8:

Table E.8 Comparison of Average Incident Duration* with and without CHART Response

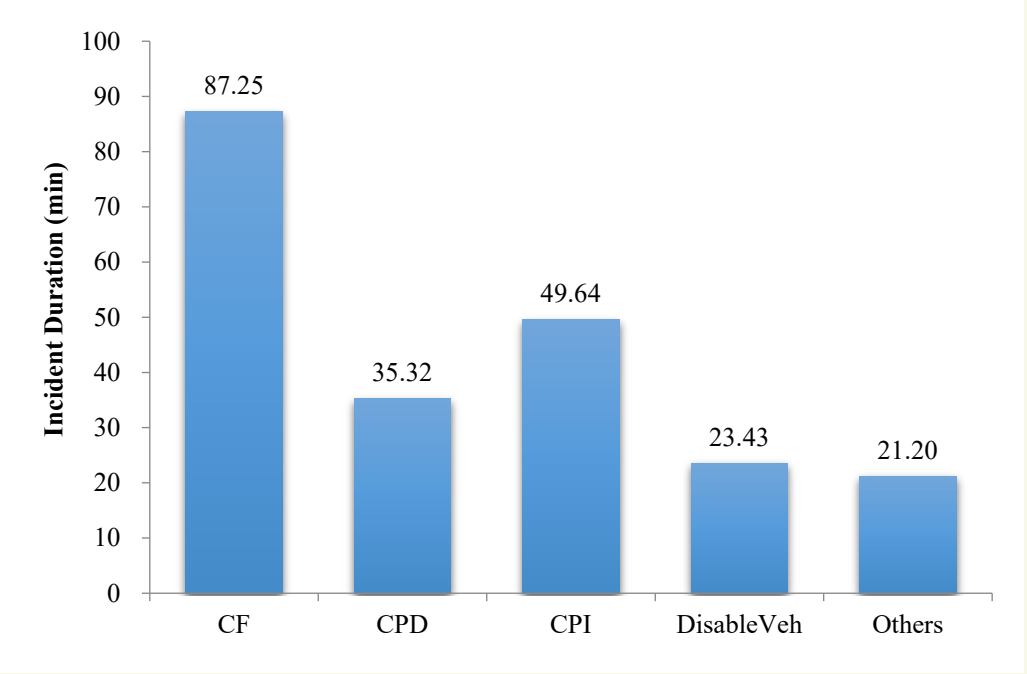
Year	With CHART (mins)	Without CHART (mins)
2020	27.04	37.02
2021	26.31	37.82
2022	26.02	37.54
2023	25.44	36.09
2024	26.01	34.34

** This analysis is based on incidents which have included information of event duration, lane blockage, and response units.*

For effective and efficient traffic management after incidents, responsible agencies can convey the information to travelers by updating the variable message signs. They can also estimate the resulting queue length and assess the need to implement detour operations and any other control strategies to mitigate congestion. To maximize the effectiveness of those operational strategies, a reliably predicted/estimated incident duration will certainly play an essential role.

Hence, this study conducted a statistical analysis of incident durations, which provides some further insights into the characteristics of incidents under various conditions. In this analysis, the distributions of average incident duration are identified by predefined categories, including Nature, County, County and Nature, Weekdays and Weekends, Peak and Off-Peak Hours, CHART Involvement, and Roads.

The average duration for incidents involving fatalities (CF) was 87 minutes, while those causing property damage (CPD) and personal injuries (CPI) lasted, on average, 35 and 50 minutes, respectively (see Figure E.1). The average duration for incidents by only disabled vehicles was 23 minutes, close to those classified as "Others" (e.g., debris, vehicles on fire, police activities, etc.).



** Note: 1. This analysis is based on incidents which have included information of event duration and nature.*

2. This analysis includes those sample data which have incident durations between 1 minute and 120 minutes.

Figure E.1 Distribution of Average Duration by Incident Nature in 2024

Resulting Benefits

The benefits due to CHART operations were estimated directly from the available data, including assistance to drivers and reductions in delay times, fuel consumption, emissions, and secondary incidents. In 2024, CHART responded to a total of 41,261 incidents and assisted 36,918 highway drivers who may otherwise have caused incidents or rubbernecking delays to highway traffic. In addition, the efficient removal of stationary vehicles and large debris from travel lanes by CHART patrol units may have prevented 961 potential lane-changing-related collisions in 2024, as vehicles approaching those conditions would have been forced to perform unsafe mandatory lane changes.

CORSIM, a traffic simulation program produced by the Federal Highway Administration (FHWA), was used to estimate the direct benefits attributed to delay reduction time, and it was discovered that various factors, including traffic and heavy vehicle volumes, the number of lane closures, the number of incident responses, and incident durations, affect the resulting delay (see Chapter 7 for further information on benefits estimate). For instance, several primary factors (such as the number of incidents eligible for the benefit estimate and the driving population's income) have increased in 2024. The ratio in difference between incident durations with and without CHART exhibits a decrease in 2024. Overall, the delay reduction due to CHART's services in 2024 (39.092 million vehicle-hours) decreased by 7.95 percent, compared to the performance in 2023 (42.467 million vehicle-hours). The combined impact of all key contributing factors has resulted in a net benefit decrease from $2,230.57M in 2023 to $2,148.69M, or, to $2,119.10M in 2024 if with the new emission parameters. A comparison of the direct benefits from reduced delay times, fuel consumption, and emissions, from 2020 to 2024, is summarized in Table E.9:

Table E.9 Comparison of Direct Benefits from 2020 to 2024

	Total Direct Benefits (million)[1,2,3,4,5]	# of Incidents Eligible for the Benefit Estimate[6]
2020	$1,080.83	28,513
2021	$1,875.25	31,253
2022	$2,030.56	32,130
2023	$2,230.57	33,297
2024a[5]	$2,148.69	34,145
2024b[5]	$2,119.10	34,145

Note: 1. Results are based on the data of the corresponding year from the U.S Census Bureau and Energy Information Administration.

2. The direct benefits represent reductions from delay time, fuel consumptions, and emissions due to the CHART effective operations.

3. The direct benefits rely on numerous factors (i.e., traffic and heavy vehicle volumes, the number of lane blockages, the number of incidents responded, and incident durations).

4. The direct benefits are estimated based on the car delay reduction occurring over all roads covered by CHART and the truck delay reduction only occurring along major roads.

5. Starting from the 2024 report, a new set of parameters for computing emission benefit is introduced to reflect recent vehicle emission standards. The results of 2024a shows the benefits computed with the original emission parameters, while the statistics of 2024b shows the same measurements but with the new parameters. See Chapter 7 for further information on the new emission parameters.

6. The direct benefits are estimated only based on the incidents causing travel lane closure(s).

Most benefits were produced from delay reductions due to CHART's efficient incident response and management, especially along the major corridors which are the primary contributors to traffic congestion in Maryland. The estimated delay reductions due to CHART's services on I-95, I-495, I-270, I-695, I-70, and I-83 are 11.74, 3.65, 1.28, 4.33, 1.80, and 0.86 million vehicle-hours, respectively, in 2024. Such direct benefits for users over each major road in 2024 are summarized in Table E.10:

Table E.10 Direct Benefits for Major Roads in 2024 due to CHART operations

Roads	Total Direct Benefits (2024a)[5] (million)[1,2,3,4]	Total Direct Benefits (2024b)[5] (million)[1,2,3,4]	# of Incidents Eligible for the Benefit Estimate
I-95	$664.42	$656.06	7,309
I-95/495	$201.90	$199.18	3,274
I-270	$69.12	$68.09	1,075
I-695	$238.57	$235.22	3,471
I-70	$101.33	$100.04	1,444
I-83	$48.78	$48.18	1,042
Others	$824.57	$812.33	16,530
Total	$2,148.69	$2,119.10	34,145

Note: 1. Results are based on the data of from the U.S Census Bureau and Energy Information Administration.

2. The direct benefits represent reductions in car/truck delay times, fuel consumption, and emissions due to the CHART effective operations.

3. The direct benefits vary with some key factors, including traffic and heavy vehicle volumes, the number of lane blockages, the number of incidents responded, and incident durations.

4.The direct benefits are estimated only based on the incidents causing travel lane closure(s).

5. Starting from the 2024 report, a new set of parameters for computing emission benefit is introduced to reflect the recent adoption in vehicle emission standards. The results in 2024a show the benefits computed with the original emission parameters, while the statistics in 2024b show the same measurements but with the new parameters. See Chapter 7 for further information on the new emission parameters.

The main contributing factors on estimating benefits are listed and tabulated as follows:

- The total number of incidents used for the benefit estimate increased by about 2.55 percent from the year 2023 to year 2024, as shown in Table E.11.
- The ratio, reflecting the difference between incident durations with CHART and those without CHART, increased from 27.09 percent in 2023 to 22.59 percent in 2024, as shown in Table E.12.
- Table E.13 shows that the adjusted AADT in 2024 decreased by 1.22 percent on the major roads in Maryland compared to 2023.
- Table E.14 shows that average truck percentage decreased in the year 2024 over all major roads in Maryland, by 0.1 percent on average.

Table E.11 The Total Number of Incidents Eligible for the Benefit Estimate

	2023	**2024**	**Δ('23 ~ '24) [2]**
No. of Incidents [1]	33,297	34,145	***2.55***

Note: 1. They only include the incidents causing main lane blockage. To estimate benefits, the incidents causing only shoulder lane blockage are excluded.

2. The percentage change in No. of Incidents (X) from Year 2023 to Year 2024 is calculated as follows: $\Delta\mathbf{X}(\%) = \frac{X_{2024}-X_{2023}}{X_{2023}} \times 100$

Table E.12 Incident duration reduction in year 2023 and 2024

	With CHART(mins) (A)	**Without CHART(mins) (B)**	**Difference(mins) (B-A)**	**Ratio in Difference ((B-A)/B)**
2023	27.42	37.61	10.19	27.09 %
2024 All year	27.90	36.04	8.14	22.59 %
2024 January to June	27.38	36.25	8.87	24.47 %
Δ('23 ~ '24 all year) [2]	1.75%	-4.17%	-20.12%	-16.61 %
Δ('23 ~ '24 Jan to June) [3]	-0.15%	-3.62%	-12.95%	-9.67 %

Note: 1. The analysis is based on incidents that have main lanes blockage.

2. The percentage change in incident duration (X) from Year 2023 to Year 2024 is calculated as follows:

$\Delta\mathbf{X}(\%) = \frac{X_{2024}-X_{2023}}{X_{2023}} \times 100$

3. The percentage change in incident duration (X) from Year 2023 to the period of January-June in Year 2024 is calculated as follows: $\Delta\mathbf{X}(\%) = \frac{X_{2024\text{ data from Jan.to June}}-X_{2023}}{X_{2023}} \times 100$. *As of July 2024, ERTs are no longer actively patrolling and are staged in high call volume areas, waiting until called upon for assistance.*

Table E.13 The adjusted AADT (with peak hour factor) for Major Roads from 2023 and 2024

	Year	I-495	I-95	I-270	I-695	MD 295	US 50	US 1	I-83	I-70	Total
$\sum_{\text{segments}}$ AADT(vplph)*PHF	**2023**	12,079	7,905	7,612	10,453	4,086	2,404	4,333	2,487	3,400	**54,756**
	2024	11,908	7,954	7,223	10,471	4,013	2,378	4,320	2,481	3,340	**54,088**
Δ('23 ~ '24) (%)*		-1.42	0.62	-5.11	0.17	-1.79	-1.08	-0.30	-0.24	-1.76	-1.22

Note: The percentage change in the adjusted AADT(X) from Year 2023 to Year 2024 is calculated as follows:

$$\Delta\mathbf{X}(\%) = \frac{X_{2024} - X_{2023}}{X_{2023}} \times 100$$

Table E.14 Truck percentage for Major Roads from year 2023 and 2024

	Year	I-495	I-95	I-270	I-695	MD 295	US 50	US 1	I-83	I-70	Average
Truck %	**2023**	7.96	9.77	3.48	6.50	1.77	5.26	3.85	10.43	9.65	**6.52**
	2024	7.08	11.23	3.67	6.37	1.86	4.66	3.88	10.49	9.37	**6.51**
Δ('23 ~ '24)(%)*		-11.06	14.94	5.46	-2.00	5.08	-11.41	0.78	0.58	-2.90	-0.10

Note: The percentage change in the truck percentage (X) from Year 2023 to Year 2024 is calculated as follows:

$$\Delta\mathbf{X}(\%) = \frac{X_{2024} - X_{2023}}{X_{2023}} \times 100$$

The following procedures are used for performing the below sensitivity analyses:

- Identifying key factors contributing to the total CHART benefits, which are: traffic volume, the number of blocked lanes, incident duration with and without CHART involvements, truck percentage, value of time, and gas price;
- Computing the marginal impact of each selected factor, using its 2024 value, but setting all other factors identical to those in 2023; and
- Following the same procedures to analyze the sensitivity of the total 2024 benefits with respect to each key factor.

The results of sensitivity analysis for each factor are shown in Table E.15. The decrease in the average adjusted AADT by 1.22 percent in 2024 contributed to a decrease of 3.48 percent in total benefit. The number of lane-blockage incidents increased by 2.55 percent in 2024, resulting in the benefit increase of 2.01 percent. Note that the ratio with respect to the performance difference between incident durations with- and without-CHART involvement decreased by 20.12 percent, and thus directly resulted in a 16.62 percent decrease in total benefit. This is likely due to the policy change in July 2024, from then ERTs stopped patrolling and temporarily stationed in the areas of high call volume , i.e., waiting until called upon for assistance. If the policy had remained unchanged, the performance difference between incident durations with- and without-CHART would have only decreased by 12.95 percent.

An increase of 3.42 percent in the total benefit is due solely to the average income raise of 4.44 percent in the MD's populations (i.e., a proxy for time value).

Table E.15 Sensitivity Analysis of key factors contributing to the Benefits (Unit: M dollar)

Benefit of the Previous Year (2023)			2,230.57
Key Factor		**Δ ('23 - '24)**	**Estimated Benefit**
Sensitivity Analysis	**Adjusted AADT**	▼1.22%	1,873.10 (▼3.48%)[1]
	Number of incidents	▲2.55%	1,915.10 (▲2.01%)
	Incident duration difference between w/ and w/o CHART — **'24 All year**	▼20.12%	1,859.79 (▼16.62%)
	Incident duration difference between w/ and w/o CHART — **'24 Jan. to June**	▼12.95%	2,014.84 (▼9.67%)
	Truck percentage	▼0.1%	2,231.14 (▲0.03%)
	Monetary unit of gas price	▼5.83%	2,228.42 (▼0.1%)
	Monetary unit of time value	▲4.44%	2,306.83 (▲3.42%)
Benefit of the Current Year (2024a)			**2,148.69 (▼3.67%)**[2]
Benefit of the Current Year (2024b)			**2,119.10 (▼5.00%)**[2]

Note: 1. The number in each parenthesis shows the percentage of benefit change from year 2023.

2. Starting from the 2024 report, a new set of parameters for computing emission benefit is introduced to reflect recent advancements in vehicle emission standards. The results in 2024a show the benefits computed with the original emission parameters, while the statistics in 2024b show the same measurements but with the new set of parameters. See Chapter 7 for further information on the new emission parameters.

Conclusions and Recommendations

Grounded in the lessons from the earlier studies, this study has conducted a rigorous evaluation of CHART's performance in 2024 and its resulting benefits under the constraints of data availability and quality. Overall, CHART has made significant progress in recording more reliable incident reports, especially after implementation of the CHART-II Database.

However, much remains to be done in terms of collecting more data and extending operations to major local arterials, if resources are available to do so. For example, data regarding the potential impacts of major incidents on local streets have not been collected by CHART. Without such information, one may substantially underestimate the benefits of CHART operations, as most incidents causing lane blockages on major commuting freeways are likely to spill congestion back to neighboring local arterials if traffic queues form more quickly than incidents are cleared. Similarly, a failure to respond to major accidents on local arterials, such as MD-355, may also significantly degrade traffic conditions on I-270. Effectively coordinating with county agencies on both incident management and operational data collection is one of CHART's major tasks.

With respect to overall performance, CHART has maintained nearly the same level of efficiency in responding to incidents and driver assistance requests in recent years. The average response time in Year 2024 was 12.73 minutes (See Table E.6). In view of the worsening congestion and the increasing number of incidents in the Washington-Baltimore region, it is commendable that CHART can maintain its performance

efficiency with approximately the same level of resources.

This study's main recommendations, based on the performance of CHART in 2024, are listed below:

- Increase the resources for CHART to sustain the high-quality incident response operation, including more staff and hardware supports.
- Provide constant training to staff in the control center responsible for recording incident related information to ensure the data quality.
- Develop and update a strategy to allocate CHART's resources between different response centers, based on their respective performance and efficiency so that they can effectively contend with the ever-increasing congestion and accompanying incidents both in urban and suburban areas.
- Coordinate with county traffic agencies to extend CHART operations to major local routes and include data collection as well as performance benefits for such roadways in the annual CHART review.
- Make CHART's data quality evaluation report available to the centers' operators for their improvement of data recording and documentation.
- Implement training sessions to educate/re-educate operators on the importance of high-quality data, and discuss how to effectively record critical performance-related information.
- Improve the data structure used in the CHART-II system for recording incident locations to eliminate the need to employ the current laborious and complex procedures.
- Document and re-investigate the database structure on a regular basis to improve the efficiency and quality of collected data.
- Document possible explanations for extremely short or long response and/or clearance times so that the results of performance analysis can be more reliable.
- Integrate police accident data efficiently with the CHART-II incident response database to have a complete representation of statewide incident records.
- Extend the CHART analysis model to investigate the relationship between the incident duration and the probability of incurring secondaries incidents.
- Incorporate the delay and fuel consumption benefits from the reduced potential secondary incidents in the CHART benefit evaluation.

Summary of Key Findings from the 2024 CHART Performance Evaluation

- Both the total number of statewide emergency responses and CHART responses slightly decreased from Year 2023 to Year 2024 (by 5.79% and 6.59%, respectively).
- Since TOC 3 relocated back to their center on July 24th, 2024, the number of responses by TOC3 increased significantly in 2024 (from 2 in 2023 to 2,909 in 2024).
- In 2024, the average incident duration with CHART was 26.01 minutes, much shorter than the average of 34.34 minutes for those incidents responded by other agencies. The reduction in the average incident duration is about 24 percent.
- Both AADT and truck percentage on most major roads did not experience major changes in 2024. The incident duration difference between with and without CHART for the entire year of 2024 is lower than that of 2023. This might be related to the pause of the CHART vehicle patrolling on the roadways.
- Among major corridors, I-95 experienced the most significant increase in emergency response frequency in 2024 compared to 2023 (by about 18%), while I-495/I-95 saw the most significant decrease (by about 26%). The total emergency response frequency on US 50 and I-695 decreased by 16% and 15%, respectively, compared to 2023.
- The total benefit of CHART operation increased by 0.11 percent, nearly the same as in 2023.
- Starting from July 2024, ERTs are no longer actively patrolling and station mainly in areas of high call volume, i.e., waiting until called upon for assistance, which partially contributes to the reduction of incident duration difference between w/ and w/o CHART.

The above changes, along with other factors, collectively contributed to the resulting direct benefits by CHART's performance in 2024.