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Performance Evaluation and Benefit Analysis For CHART

– Coordinated Highways Action Response Team –

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Performance Evaluation of CHART

The Real-Time Incident Management System (Year 2020)

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EXECUTIVE SUMMARY

Objectives

This report presents the performance evaluation study of the Coordinated Highways Action Response Team (CHART) for 2020, including its operational efficiency and resulting benefits. The research team at the Department of Civil Engineering at the University of Maryland, College Park (UM), has conducted the annual CHART performance analysis over the past twenty-three years for the Maryland Department of Transportation State Highway Administration (MDOT SHA).

Similar to 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 focused 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 2020 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 with statistical methods.

Available Data for Analysis

Upon a request made by MDOT 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 also because of the Statewide Operations Center's (SOC) opening 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, UM (Chang and Point-Du- Jour, 1998) was contracted to work jointly with MDOT 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 collected all previous performance records for a scrupulous evaluation.

The 1997 CHART performance evaluation had the advantage of possessing 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 reflect the need to keep an extensive operational record in order to justify CHART's costs and to evaluate the benefits of the emergency response operations. Due to CHART's efficient data collection, the documentation of lane-closure-related incidents increased from 2,567 in 1997 to 34,590 in 2020.

Table E.1 shows the total number of emergency response operations assiduously documented from 2016 to 2020.

Table E.1 Summary of the Total Number of Emergency Responses from 2016 to 2020

	2016	2017	2018	2019	2020	Δ (2020-2019)
Incidents Only	37,566 (30,314)	37,100 (30,335)	41,247 (34,692)	38,383 (31,750)	34,590 (26,702)	-9.88% (-15.90%)
Total *	81,853 (72,362)	81,299 (72,381)	88,138 (79,956)	79,506 (71,233)	70,115 (60,665)	-11.81% (-14.84%)

**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.

It should be noted that CHART has responded to fewer incidents this year than in the past four years. This may be due to a decrease in networkwide incidents.

Evolution of the Evaluation Work

CHART has consistently worked to improve its data recording for both major and minor incidents over the past seventeen years, which accounts for the substantial improvements in data quality and quantity. The evaluation work has also been advanced by the improved availability of data. Assessing the quality of available data and using only reliable data in the benefit analysis is imperative. Therefore, since 1999, the performance evaluation reports have included data quality analysis, ensuring continued advancement in the quality of incident- related data so as to reliably estimate all potential benefits of CHART operations.

Since February 2001, all incidents requesting emergency assistance have been recorded in the CHART-II information system, regardless of CHART's involvement. This has significantly enriched the available data for analysis. In the current CHART database system, most incident-related data can be generated directly for computer processing with the exception of incident-location-related information, which 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 possessing 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 2020 incident data results indicate that there were 3,221 incidents resulting in a one-lane blockage, 8,205 incidents causing two-lane closures, and 5,111 incidents blocking three or more lanes. In addition, either disabled vehicles or minor incidents caused a total of 41,409 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

	2016	2017	2018	2019	2020	Δ (2020-2019)
Shoulder[2]	50,519	51,115	54,630	48,485	41,409	-14.59%
1 lane	3,962	3,727	3,948	3,480	3,221	-7.44%
2 lanes[3]	8,746	8,383	9,589	8,823	8,205	-7.00%
3 lanes[3]	3,042	2,859	3,086	2,965	2,780	-6.24%
≥ 4 lanes[3]	2,327	2,114	2,458	2,301	2,331	**1.30%**

**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., two-lane blockage can either be two travel lanes or one travel lane and one shoulder blockage)

Most of these incidents/disabled vehicles were distributed along six major commuting corridors: I-495/95, which experienced a total of 10,339 incidents/disabled vehicles in 2020; and I-695, I-95, US-50, I/MD-295, and I-270, which experienced 8,025, 12,937, 6,942, 2,694, and 4,058 incidents/disabled vehicles, respectively. CHART managed an average of 35 emergency requests per day on I-95 alone, and 28, 22, 18, 7, and 11 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 2016 and 2020 is shown in Table E.3:

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

	2016	2017	2018	2019	2020	Δ (2020 - 2019)
I-495/95	12,168	12,570	11,807	10,589	10,339	-2.36%
I-695	11,029	12,249	11,752	10,705	8,025	-25.04%
I-95	12,751	11,259	15,619	14,729	12,937	-12.17%
US-50	8,077	8,053	7,940	7,208	6,492	-9.93%
I/MD-295	4,217	3,459	3,578	3,152	2,694	-14.53%
I-270	5,087	4,998	5,086	4,892	4,058	-17.05%

** 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 peak hours in 2020 are shown in Table E.4. The highest frequency of incidents occurred on the I-95 southbound segment between Exits 56 and 57, and the I-95 northbound segment between Exits 55 and 56 in AM and PM peaks, respectively. The northbound segment on I-95 between Exits 67 and 74 ranked the first with the respect to the number of disabled vehicle requests in 2020 in both AM and PM peak hours.

Table E.4 Top 10 Freeway Segments with the Most Incidents/Disabled Vehicles in 2020

	Incidents				Disabled vehicles			
	AM Peak		PM Peak		AM Peak		PM Peak	
1	I-95 S	Exit 56&57	I-95 N	Exit 55&56	I-95 N	Exit 67&74	I-95 N	Exit 67&74
2	I-695 IL	Exit 43&44	I-95 N	Exit 67&74	I-95 S	Exit 67&74	I-95 N	Exit 61&62
3	I-95 N	Exit 55&56	I-95 S	Exit 56&57	I-495 IL	Exit 13&15	US 50 W	Exit 16&21
4	I-495 OL	Exit 27&28	I-695 IL	Exit 11&12	I-495 IL	Exit 7&9	I-95 S	Exit 67&74
5	I-95 S	Exit 67&74	I-695 IL	Exit 43&44	I-495 OL	Exit 27&28	I-495 OL	Exit 9&11
6	I-95 S	Exit 93&100	I-95 N	Exit 64&67	I-495 IL	Exit 9&11	I-695 IL	Exit 17&18
7	I-95 N	Exit 89&93	I-95 N	Exit 74&77	US 50 W	Exit 32&37	I-695 OL	Exit 17&18
8	I-95 S	Exit 58&59	I-95 S	Exit 49&50	I-95 S	Exit 56&57	I-95 N	Exit 55&56
9	I-495 OL	Exit 29&30	I-495 IL	Exit 33&34	I-495 IL	Exit 22&23	US 50 E	Exit 16&21
10	I-95 N	Exit 100&109	I-95 S	Exit 67&74	I-495 OL	Exit 30&31	I-495 IL	Exit 33&34

** 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 commuting freeways did not block traffic for more than one hour. For instance, about 73% of incidents/disabled vehicles had durations shorter than 30 minutes in 2020. 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 2016 to 2020 are summarized in Table E.5:

Table E.5 Distribution* of Incidents/Disabled Vehicle Duration from 2016 to 2020

Duration(Hrs)	2016	2017	2018	2019	2020
D < 0.5	75%	76%	74%	73%	73%
0.5 ≤ D < 1	14%	14%	15%	16%	15%
1 ≤ D < 2	6%	6%	6%	7%	7%
2 ≤ D	5%	4%	5%	5%	5%

** This analysis is based on incidents and disabled vehicles (i.e., assists to drivers) that 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 major commuting highway corridors like I-95, I-270, 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. MDOT 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 12.17, 12.98, 11.42, 14.32, and 9.03 minutes for TOC-3, TOC-4, TOC-7, SOC and AOC, respectively, in 2020. This table also shows that TOC-3 and TOC-4 provided more prompt response services in 2020 than in 2019. In addition, TOC-4 and TOC-7 demonstrated faster responses during their operational hours than non-operational hours. Note that incidents/disabled vehicles included in this analysis were responded to by various units, including CHART and non-CHART agencies:

Table E.6 Evolution of Response Times* by Center from 2016 to 2020

Response Time (mins)	2016	2017	2018	2019	2020		
					During OH	After OH	Overall
TOC-3	13.05	12.33	13.00	12.99	12.18 (4,734)	10.31 (32)	12.17 (4,766)
TOC-4	12.49	13.17	14.01	13.40	12.97 (4,916)	14.39 (39)	12.98 (4,955)
TOC-7	10.88	10.24	11.46	11.38	11.39 (2,635)	13.18 (48)	11.42 (2,683)
ESTO	7.89	6.95	7.12	6.84	N/A	N/A	N/A
SOC	13.65	13.34	13.78	13.93	14.32 (4,684)	N/A	14.32 (4,684)
AOC	7.23	7.66	8.74	8.99	9.03 (8,066)	N/A	9.03 (8,066)
OTHER	5.24	6.84	8.91	11.68	N/A	2.53 (1)	2.53 (1)
Weighted Average	**11.69**	**11.44**	**11.99**	**11.88**	**11.64 (25,035)**	**12.72 (120)**	**11.64 (25,155)**

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

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

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

4. OH stands for Operational Hours: TOCs 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-day-a-week basis.

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

6. ESTO's response records are absorbed by SOC as of Oct 6th, 2019.

Table E.7 shows that incidents receive more prompt response times than disabled vehicles during both operational and non-operational hours.

Table E.7 Comparisons* of CHART Response Performance during and after Operational Hours

Response Time (mins)	Operational Hours		Non-operational Hours		Total		
	Incident	Disabled Vehicle	Incident	Disabled Vehicle	Incident	Disabled Vehicle	Sub-total
TOC-3	12.40 (3,256)	12.70 (1,487)	12.28 (25)	4.93 (6)	12.40 (3,281)	12.67 (1,493)	12.48 (4,774)
TOC-4	12.91 (3,569)	16.63 (1,414)	14.01 (36)	17.96 (7)	12.92 (3,605)	16.64 (1,421)	13.97 (5,026)
TOC-7	11.69 (2,028)	12.48 (593)	12.19 (38)	16.68 (12)	11.69 (2,066)	12.56 (605)	11.89 (2,671)
SOC	14.64 (3,020)	19.11 (1,337)	N/A	N/A	14.64 (3,020)	19.11 (1,337)	16.01 (4,357)
AOC	7.24 (5,371)	12.04 (2,387)	N/A	N/A	7.24 (5,371)	12.04 (2,387)	8.71 (7,758)
OTHER	N/A	N/A	2.99 (2)	N/A	2.99 (2)	N/A	2.99 (2)
Weighted Average	**11.21 (17,244)**	**14.42 (7,218)**	**12.68 (101)**	**14.22 (25)**	**11.22 (17,345)**	**14.42 (7,243)**	**12.16 (24,588)**

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

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

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

4. OH stands for Operational Hours: TOCs 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 30, 2017. SOC and AOC operate on a 24 hour/seven-day-a-week basis.

5. The number in each parenthesis indicates the data availability.

The 2020 data also 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 in 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 responded by CHART and those managed by other agencies. For example, the difference in average response times for one-lane-blockage incidents with and without CHART involvement is about 12.37 minutes.

The duration of incidents managed by CHART response units averaged 25.35 minutes, shorter than the average duration of 37.02 minutes for incidents managed by other agencies. On average, CHART operations in 2020 reduced the average incident duration by about 31.5%.

Performance improvement of CHART operations from years 2016 to 2020 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)
2016	24.06	35.52
2017	24.01	34.88
2018	25.42	33.08
2019	25.75	33.91
2020	25.35	37.02

** Note: 1. This analysis is based on incident records which have included the information of event duration, lane blockage, and response units.*

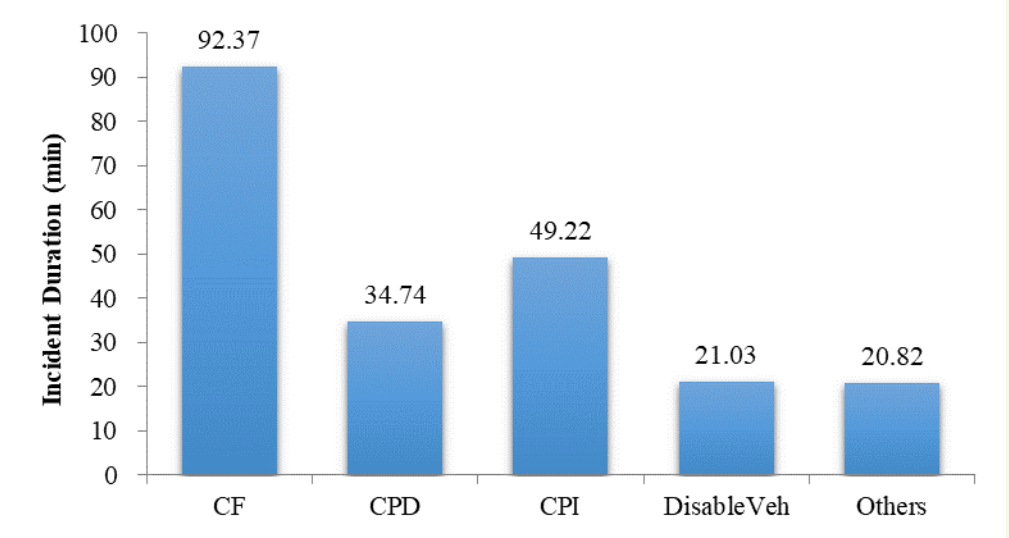
2. This analysis includes those sample events which have incident durations between 1 minute and 120 minutes.

3. The numbers are the weighted average of incidents with different lane blockages, including shoulder only blockage.

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 insight 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 of incidents involving fatalities (CF) was 92 minutes, while incidents with property damage (CPD) and personal injuries (CPI) lasted, on average, 35 and 49 minutes, respectively (see Figure E.1). The average duration of disabled vehicle incidents was 21 minutes, similar to those classified as “Others” (e.g., debris, vehicles on fire, police activities, etc.).



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

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

Figure E.1 Distribution of Average Incident Duration by Nature in 2020

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 2020, CHART responded to a total of 34,590 lane blockage incidents and assisted 35,525 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 800 potential lane-changing-related collisions in 2020, 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. 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, in 2020 several primary factors, such as AADT and the number of incident responses, have noticeably decreased compared with 2019 because of the COVID-19 pandemic, while other factors such as truck percentage and incident duration difference with and without CHART have increased. The reduction in delay due to CHART's services in 2020 (23.52 million vehicle hours) decreased by 28% in comparison with the performance in 2019 (32.58 million vehicle-hours). Such reduction consequently results in a decrease of the total benefits by approximately 22%, from $1,393.38 M to $1,080.83 M. A comparison of the direct benefits from reduced delay times, fuel consumption, and emissions from 2016 to 2020 is summarized in Table E.9:

Table E.9 Comparison of Direct Benefits from 2016 to 2020

	Total Direct Benefits (million)[1,2,3,4]	# of Incidents Eligible for the Benefit Estimate[5]
2016	$1,511.97	31,172
2017	$1,465.62	29,986
2018	$1,311.89	33,243
2019	$1.393.38	30,793
2020	$1,080.83	28,513

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

Most benefits were produced by delay reductions due to CHART's efficient incident response and management, especially along the major corridors that are the primary contributors to traffic congestion in Maryland. The estimated delay reduction due to CHART's services on I-95, I-495, I-270, I-695, I-70, and I-83 are 4.61, 3.29, 1.04, 3.46, 1.50, and 0.45 million vehicle-hours, respectively, in 2020. Such direct benefits for each major road in 2020 are summarized in Table E.10:

Table E.10 Direct Benefits for Major Roads in 2020 due to CHART Operations

Roads	Total Direct Benefits (million)[1,2,3]	# of Incidents Eligible for the Benefit Estimate
I-95	$219.43	4,976
I-495/95	$154.22	3,310
I-270	$47.62	975
I-695	$159.13	3,297
I-70	$70.56	1,404
I-83	$21.00	662
Others	$408.87	13,889
Total	$1,080.83	28,513

** 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 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).

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

- The total number of eligible incidents for the benefit estimate decreased by about 7.40% from 2019 to 2020, as shown in Table E.11.
- The ratio reflecting the difference between incident duration with CHART and those without CHART increased from 22.49% in 2019 to 28.41% in 2020, as shown in Table E.12.
- Table E.13 shows that the adjusted AADT with peak hour factors in 2020 for major roads in Maryland compared with 2019 generally decreased by 18.30%.
- As shown in Table E.14, truck percentage on major corridors in 2020 increased by 26.49%.

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

	2019	2020	Δ('19 ~ '20)
No. of Incidents	30,793	28,513	***-7.40%***

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

2. The percentage change in No. of Incidents (X) from 2019 to 2020 is calculated as follows: $\Delta \mathbf{X}(\%) = \frac{X_{2020} - X_{2019}}{X_{2019}} \times 100$

Table E.12 Incident Duration Reduction in 2019 and 2020

	With CHART(mins) (A)	Without CHART(mins) (B)	Difference(mins) (B-A)	Ratio in Difference ((B-A)/B)
2019	27.67	35.70	8.03	***22.49%***
2020	27.06	37.80	10.74	***28.41%***
Δ('19 ~ '20) *	-2.20%	0.25%	33.73%	***26.30%***

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

2.The percentage change in incident duration (X) from 2019 to 2020 is calculated as follows: $\Delta \mathbf{X}(\%) = \frac{X_{2020} - X_{2019}}{X_{2019}} \times 100$

Table E.13 The Adjusted AADT (with Peak Hour Factor) for Major Roads from 2019 to 2020

	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	**2019**	12,967	8,614	7,444	11,336	4,369	2,499	4,807	2,866	3,489	***58,391***
	2020	10,502	6,827	6,127	9,316	3,600	2,082	4,115	2,293	2,843	***47,706***
Δ('19 ~ '20) (%)*		-19%	-21%	-18%	-18%	-18%	-17%	-14%	-20%	-19%	***-18.30%***

Note: The percentage change in the adjusted AADT(X) from 2019 to 2020 is calculated as follows: $\Delta \mathbf{X}(\%) = \frac{X_{2020} - X_{2019}}{X_{2019}} \times 100$

Table E.14 Truck Percentage for Major Roads from 2019 to 2020

	Year	I-495	I-95	I-270	I-695	MD 295	US 50	US 1	I-83	I-70	Average
Truck %	**2019**	7.12	12.46	5.25	6.63	2.56	9.06	4.08	7.03	8.24	***6.94***
	2020	9.08	15.62	6.96	8.32	3.03	9.82	4.85	10.54	10.73	***8.77***
Δ('19 ~ '20)(%)*		27.5%	25.4%	32.5%	25.6%	18.4%	8.4%	18.9%	49.9%	30.2%	***26.49%***

Note: The percentage change in the truck percentage from 2019 to 2020 is calculated as follows: $\Delta \mathbf{X}(\%) = \frac{X_{2020} - X_{2019}}{X_{2019}} \times 100$

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 2020 value, but setting all other factors identical to those in 2019; and
- following the same procedures to analyze the sensitivity of the total 2020 benefits with respect to each key factor.

The results of sensitivity analysis for each factor are shown in the Table E.15. The decrease in the average adjusted AADT by 18.30% in 2020 contributed to a decrease of 43.98% in the total benefit while the 26.49% increase in truck percentage resulted in an increase of 0.83% in the benefit. The number of eligible incidents decreased by 7.40% in 2020, resulting in the benefit decrease of 5.17%. Note that the increasing ratio of the performance difference between incident durations with CHART and those without CHART by 26.30% resulted in a 26.30% increase in the total benefit. The total benefits increase by 6.69% was due solely to the increase of 6.49% in drivers' income (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 (2019)			**1,393.38**
Key Factor		**Δ ('19 - '20)**	**Estimated Benefit**
Sensitivity Analysis	**Adjusted AADT**	▼18.30%	780.55 (▼43.98%)
	Number of incidents	▼7.40%	1,321.41 (▼5.17%)
	Incident duration difference between w/ and w/o CHART	▲26.30%	1,759.79 (▲26.30%)
	Truck percentage	▲26.49%	1,404.98 (▲0.83%)
	Monetary unit of gas price	▼16.12%	1,390.64 (▼0.20%)
	Monetary unit value of time	▲6.49%	1,486.62 (▲6.69%)
Benefit of the Current Year (2020)			**1,080.83** (▼22.43%)

** The number in each parenthesis shows the percentage of benefit change from year 2019.*

Conclusions and Recommendations

Grounded on the lessons from the earlier studies, this study has conducted a rigorous evaluation of CHART's performance in 2020 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 2020 was 11.64 minutes. 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 2020, 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 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 of employing 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 2020 CHART Performance Evaluation

- Both the number of statewide emergency responses and CHART responses decreased significantly (about 11.81% and 14.84%) from 2019 to 2020, due likely to the impact of the COVID-19 pandemic. CHART responded to 14.84% less events in 2020 than in 2019.
- The average response time was shorter in 2020 compared to that in 2019, especially for TOC-3 and TOC-4.
- In 2020, the average incident duration with CHART was 25.35 minutes, shorter than the average of 37.02 minutes for those incidents responded by other agencies. The reduction in the average incident duration is about 32%. The average incident duration with CHART of 25.35 minutes was shorter than that in 2019 (i.e., 25.75 minutes).
- Despite the reduction of about 15% in shoulder lane blockages in 2020, those incidents blocking multiple travels lanes exhibited less significant decrease even under the substantially lower traffic volumes due to the COVID-19 pandemic. In fact, 2020 records show a slight increase in incidents blocking 4+ lanes, compared to 2019.
- Among major corridors, I-695 experienced the most significant reduction in its incidents/disabled vehicles frequency in 2020, compared to 2019 (about 25%); the total incidents/disabled vehicles frequency on I-495/I-95 is at the same level as in 2019.
- The total benefit of CHART operation decreased by 22.43%, mainly due to the significant reduction (18.30%) of adjusted AADT in 2020.

The aforementioned changes, along with other factors, collectively contributed to the direct benefits by CHART's performance in 2020.