To: Glenn McLaughlin and Mohammed Raqib
CC: Tom Costello and Warren Henry
From: Yao Cheng, Hyeonmi Kim and Gang-Len Chang
Date: 7/6/2021
Re: CHART Benefit Estimation for Year 2020

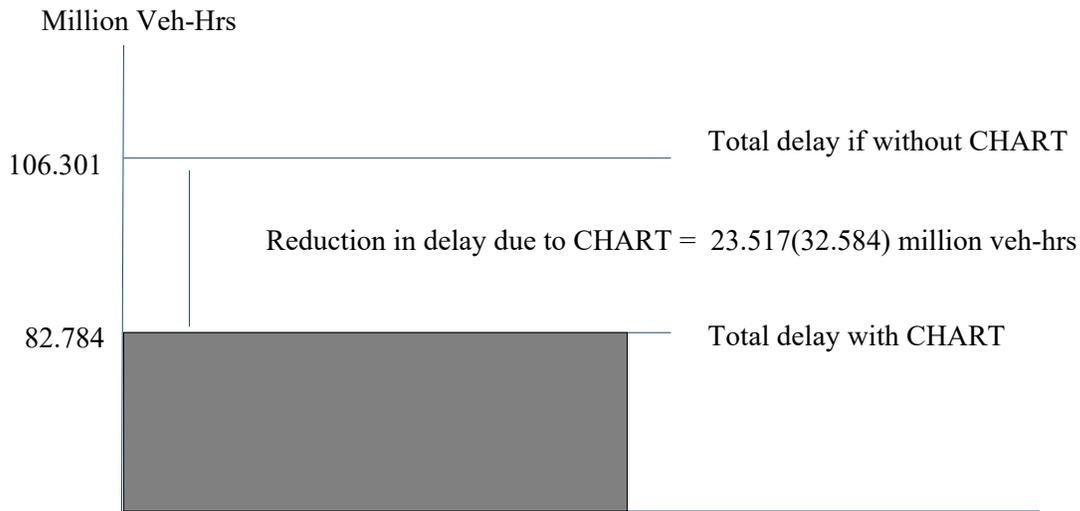## < Estimated Benefits for Year 2020>

Reduction due to CHART			Amount	Unit rate	In M Dollar
Delay (M veh-hr)	**Truck**		1.49 (1.55)	Driver $21.75/hour (20.60) [1]	32.45 (31.93)
				Cargo $45.40/hour	67.74 (70.38)
	Car		22.03 (31.03)	$42.80/hour (39.85) [2]	942.71 (1,236.81)
Fuel Consumption (M gallon)			4.70 [4] (6.16)	Gasoline $2.26/gal (2.69) [3]	11.01 (17.05)
				Diesel $2.56/gal (3.06) [3]	
Emissions	**HC (ton)**		307.44 (425.97)	$6,700/ton	26.91 (37.20)
	CO (ton)		3,453.07 (4,784.28)	$6,360/ton	
	NO (ton)		147.24 (204.01)	$12,875/ton	
	CO_2 (metric ton)		43,372.14 (56,344.93)	$23/metric ton [5]	
Total			**$1,080.83 (1,393.38)**		

<Note>
- The number in each parenthesis is the data in year 2019.
- All values are rounded to the nearest hundredth in this table only for the presentation purpose, since the actual values need more spaces to be presented. For example, the benefit from truck drivers =1,492,170.68… veh-hr * $21.75hr = $32,447,251.40…

<Source>
1. The truck driver's unit cost is based on the information from the Bureau of Labor Statistics in year 2020.
2. The car driver's unit cost is based on household income by the U.S. Census Bureau (2020).
3. The gasoline and diesel unit costs are from the Energy Information Administration in year 2020.
4. The fuel consumption was computed based on the rate of 0.156 gallons of gas per hour for passenger cars from the Ohio Air Quality Development Authority and the rate of 0.85 gallon per hour for trucks from the literature "Heavy-Duty Truck Idling Characteristics-Results from a Nationwide Truck Survey" by Lutsey et al. and the Environmental Protection Agency (EPA).
5. This value is computed based on the unit rates of 19.56 lbs CO2/gallon of gasoline and 22.38 lbs CO2/gallon of diesel from the Energy Information Administration and $23/metric ton of CO2 from CBO (Congressional Budget Office)'s cost estimate for S. 2191, America's Climate Security Act of 2007.

Million Veh-Hrs

106.301 ——————— Total delay if without CHART

Reduction in delay due to CHART = 23.517(32.584) million veh-hrs

82.784 ——————— Total delay with CHART

* The number in the parenthesis shows the data from year 2019

Figure 1 Reduction in Delay due to CHART in Year 2020

The total benefits decreased from 1,393.38 million dollars in 2019 to 1,080.83 million dollars in 2020. The main factors contributing to the reduction in benefits are listed and tabulated below:

- The total number of incidents with sufficient recorded information for estimated benefits decreased by 7.40 percent from year 2019 to year 2020 as shown in Table 1.

- The ratio in Table 2, reflecting the difference between the average incident duration under CHART and that without CHART, increased from 22.49 percent in 2019 to 28.41 percent in 2020.

- Table 3 shows that the adjusted AADT with peak hour factors in 2020 for major roads in Maryland, compared with 2019, generally decreased by 18.30 percent.

- As shown in Table 4, truck percentage on major corridors in 2020 increased by 26.49 percent.

Table 1 The Total Number of Incidents Eligible for the Benefit Estimate

	2019	2020	Δ('19 ~ '20)
No. of Incidents [1]	30,793	28,513	*-7.40%*

Note: 1.The incidents causing main lanes blockage are only included. The incidents causing only shoulder lanes blockage are excluded for the benefit analysis.

2. The percentage change in No. of Incidents (X) from Year 2019 to Year 2020 is calculated as follows:

$$\Delta \mathbf{X}(\%) = \frac{X_{2020} - X_{2019}}{X_{2019}} \times 100$$

Table 2 Average Incident Duration with and without CHART in Year 2019 and Year 2020 [1]

	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	9.08	*28.41%*
Δ('19 ~ '20) *	-2.20%	0.25%	33.73%	*26.30%*

Note: 1. The analysis is based on those incidents causing main lane blockage, but not with those for shoulder lane blockage only.

2. The percentage change in incident duration (X) from Year 2019 to Year 2020 is calculated as follows:

$$\Delta \mathbf{X}(\%) = \frac{X_{2020} - X_{2019}}{X_{2019}} \times 100$$

Table 3 The adjusted AADT (with peak hour factor) for Major Roads from Year 2019 to Year 2020

	Year	I-495	I-95	I-270	I-695	MD 295	US 50	US 1	I-83	I-70	Total
$\sum_{segments}$ 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 Year 2019 to Year 2020 is calculated as follows:

$$\Delta \mathbf{X}(\%) = \frac{X_{2020} - X_{2019}}{X_{2019}} \times 100$$

Table 4 Truck Percentage for Major Roads from Year 2019 to Year 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 Year 2019 to Year 2020 is calculated as follows:

$$\Delta \mathbf{X}(\%) = \frac{X_{2020} - X_{2019}}{X_{2019}} \times 100$$

The following procedures are used for sensitivity analyses:

- Identifying key factors contributing to the total CHART benefits, which are: traffic volume, the number of incidents resulting in lane blockage, incident duration with and without CHART involvements, truck percentage, value of time, and gas price;

- Computing the marginal impacts 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 5. The decrease in the average adjusted AADT by 18.30 percent in 2020 contributed to a decrease of 43.98 percent in the total benefit while the 26.49 percent increase in truck percentage resulted in an increase of 0.83 percent in the benefit. The number of eligible incidents decreased by 7.40 percent in 2020, resulting in the benefit decrease of 5.17 percent. Note that the increasing ratio of the performance difference between incident durations with CHART and those without CHART by 26.30 percent resulted in a 26.30 percent increase in the total benefit. The total benefits increase by 6.69 percent due solely to the increase of 6.49 percent in drivers' income (i.e., a proxy for time value).

Table 5 Sensitivity Analysis of key factors contributing to the Benefits (Unit: M dollar)

Benefits of the Previous Year (2019)		Δ ('19 - '20)	1,393.38
Key Factor		**Δ ('19 - '20)**	**Benefit difference**
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 of time value	↑ 6.49%	1,486.62 (↑6.69%)
Benefits of the Current Year (2020)			**1,080.83 (↓22.43%)**

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