Introduction

The Federal Highway Administration (FHWA) recently published a report in which national KABCO-level crash costs were derived and recommended[1]. Additionally, the report described a method for converting these values to account for the economic conditions of each state, including Massachusetts. This memo provides the national crash costs provided by the FHWA report, the costs adjusted for Massachusetts as described in the report, and average costs for various facility types in Massachusetts. This memo was prepared using crash costs in 2016 dollars (as estimated by Harmon et al., 2018[1]). This memorandum describes Massachusetts crash costs in 2019 dollars.

National Crash Costs by Crash Severity

The FHWA report derived and recommended comprehensive crash unit costs at each crash severity level. These crash costs are called "comprehensive" because they include both economic costs (i.e., lost wages, property damage, etc.) and costs from monetizing changes in quality-adjusted life years (QALY). National comprehensive crash costs, as recommended by FHWA, are provided below in Table 1, along with their economic and QALY components, in 2016 dollars.

Table 1 - National Recommended KABCO Crash-Level Economic, QALY, and Comprehensive Costs in 2016 Dollars

Crash Severity	KABCO	Economic Crash Unit Costs	QALY Crash Unit Costs	Comprehensive Crash Unit Costs	Recommended Comprehensive Crash Unit Costs
Fatal Crash	K	$1,722,991	$9,572,411	$11,295,402	$11,295,400
Suspected Serious Injury Crash	A	$130,068	$524,899	$654,967	$655,000
Suspected Minor Injury Crash	B	$53,700	$144,792	$198,492	$198,500
Possible Injury Crash	C	$42,536	$83,026	$125,562	$125,600
Property Damage Only	O	$11,906	$0	$11,906	$11,900

Massachusetts-Adjusted Crash Costs by Severity

FHWA recommends adjusting the national costs to Massachusetts using per capita income (PCI); national and Massachusetts PCI can be used to generate an adjustment factor by taking the ratio of Massachusetts PCI to national PCI. In the report, this calculation was performed for each state, with Massachusetts's adjustment factor being provided as 1.31401. Using this factor, KABCO crash-level crash costs have been calculated for Massachusetts and are reported in Table 2.

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[1] Harmon, T., G. Bahar, & F. Gross. *Crash Costs for Highway Safety Analysis.* Report No. FHWA-SA-17-071. Federal Highway Administration, Washington, D.C. January 2018.

Table 2 - Massachusetts Recommended KABCO Crash-Level Economic, QALY, and Comprehensive Costs in 2016 Dollars

Crash Severity	KABCO	Economic Crash Unit Costs	QALY Crash Unit Costs	Comprehensive Crash Unit Costs	Recommended Comprehensive Crash Unit Costs
Fatal Crash	K	$2,264,027.40	$12,578,243.78	$14,842,271.18	$14,842,300
Suspected Serious Injury Crash	A	$170,910.65	$689,722.53	$860,633.19	$860,700
Suspected Minor Injury Crash	B	$70,562.34	$190,258.14	$260,820.47	$260,800
Possible Injury Crash	C	$55,892.73	$109,096.99	$164,989.72	$165,000
Property Damage Only	O	$15,644.60	$0.00	$15,644.60	$15,600

Annual Adjustment

These costs are provided in 2016 dollars. To adjust these costs to dollars in another year, the FHWA report recommends growing the economic and QALY costs separately. To convert the economic costs, the Consumer Price Index (CPI) is used; to convert the QALY costs, the Median Usual Weekly Earnings Index (MUWE) is used. Using the CPI and MUWE index values for the desired year compared to 2016 allows the analyst to convert these costs to that year. Once adjusted, these values can be summed to provide the new comprehensive crash cost.

The Bureau of Labor Statistics (BLS) provides regular data on the CPI and MUWE. Output from the CPI Calculator[2] indicates the CPI ratio from 2016 to 2019 is 1.065, meaning economic costs are increased by 6.5 percent. MUWE data are provided quarterly in current dollars and by number of workers[3]. The average MUWE for 2016, weighted by workers, is $833, while for 2019 it is $917, resulting in a MUWE growth ratio of 1.10, meaning QALY costs should be grown by 10 percent. Economic and QALY costs are multiplied by relevant factors and the resulting 2019 costs are summarized in Table 3.

Table 3 – Summary of 2019 KABCO-Level Crash Costs

Severity	Economic Crash Unit Costs, 2016	Economic Crash Unit Costs, 2019	QALY Crash Unit Costs, 2016	QALY Crash Unit Costs, 2019	Comprehensive Crash Unit Costs, 2019	Recommended Comprehensive Crash Unit Costs, 2019
K	$2,264,027.40	$2,411,189.18	$12,578,243.78	$13,846,638.11	$16,257,827.29	$16,257,800
A	$170,910.65	$182,019.84	$689,722.53	$759,274.38	$941,294.22	$941,300
B	$70,562.34	$75,148.89	$190,258.14	$209,443.83	$284,592.73	$284,600
C	$55,892.73	$59,525.76	$109,096.99	$120,098.37	$179,624.12	$179,600
O	$15,644.60	$16,661.50	$0.00	$0.00	$16,661.50	$16,700

[2] CPI Inflation Calculator. Available online: https://data.bls.gov/cgi-bin/cpicalc.pl

[3] Department of Labor. "Usual Weekly Earnings of Wage and Salary Workers Second Quarter 2020". Available online: https://www.bls.gov/news.release/pdf/wkyeng.pdf.

Average Costs by Facility Type

MassDOT developed average crash costs for standard facility types in the State. These are weighted based on average severity distributions of crashes at these facilities. VHB obtained crash proportions by querying crash data for 2013 through 2017 in IMPACT[4]. For each facility type, the average total crash costs were calculated using Equation 1, the average KABC (sometimes referred to as fatal and injury, or FI) crash costs were calculated using Equation 2, average KAB crash costs were calculated using Equation 3, and the average KA crash costs were calculated using Equation 4.

$$\$_{Average,All} = \frac{N_{Crashes,K}*\$_{Mass,K}+N_{Crashes,A}*\$_{Mass,A}+N_{Crashes,B}*\$_{Mass,B}+N_{Crashes,C}*\$_{Mass,C}+N_{Crashes,O}*\$_{Mass,O}}{N_{Crashes,K}+N_{Crashes,A}+N_{Crashes,B}+N_{Crashes,C}+N_{Crashes,O}}$$

Equation 1

$$\$_{Average,FI} = \frac{N_{Crashes,K}*\$_{Mass,K}+N_{Crashes,A}*\$_{Mass,A}+N_{Crashes,B}*\$_{Mass,B}+N_{Crashes,C}*\$_{Mass,C}}{N_{Crashes,K}+N_{Crashes,A}+N_{Crashes,B}+N_{Crashes,C}}$$

Equation 2

$$\$_{Average,KAB} = \frac{N_{Crashes,K} * \$_{Mass,K} + N_{Crashes,A} * \$_{Mass,A} + N_{Crashes,B} * \$_{Mass,B}}{N_{Crashes,K} + N_{Crashes,A} + N_{Crashes,B}}$$

Equation 3

$$\$_{Average,KA} = \frac{N_{Crashes,K}*\$_{Mass,K}+N_{Crashes,A}*\$_{Mass,A}}{N_{Crashes,K}+N_{Crashes,A}}$$

Equation 4

where:

- $\$_{Average,All}$ is the average comprehensive cost for all crashes for the subject facility type;
- $\$_{Average,KA}$ is the average comprehensive cost for KA crashes for the subject facility type;
- $\$_{Average,KAB}$ is the average comprehensive cost for KAB crashes for the subject facility type;
- $\$_{Average,KABC}$ is the average comprehensive cost for KABC crashes for the subject facility type;
- $N_{Crashes,K}$ is the number of fatal crashes in the SPF data for the subject facility type;
- $\$_{Mass,K}$ is the comprehensive cost for a fatal crash in Massachusetts in 2019 dollars, $16,257,800 per Table 4;
- $N_{Crashes,A}$ is the number of suspected serious injury[5] crashes (o in the SPF data for the subject facility type;
- $\$_{Mass,A}$ is the comprehensive cost for an incapacitating injury crash in Massachusetts in 2019 dollars, $941,300 per Table 4;

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[4] Mass.gov. "IMPACT Home". Available online: https://apps.impact.dot.state.ma.us/cdp/home.

[5] Previously known as "incapacitating injury" crashes.

- $N_{Crashes,B}$ is the number of suspected minor injury[6] crashes in the SPF data for the subject facility type;
- $\$_{Mass,B}$ is the comprehensive cost for a non-incapacitating injury crash in Massachusetts in 2019 dollars, $284,600 per Table 4;
- $N_{Crashes,C}$ is the number of possible injury crashes in the SPF data for the subject facility type;
- $\$_{Mass,C}$ is the comprehensive cost for a possible injury crash in Massachusetts in 2019 dollars, $179,600 per Table 4;
- $N_{Crashes,O}$ is the number of PDO crashes in the SPF data for the subject facility type; and
- $\$_{Mass,O}$ is the comprehensive cost for a PDO crash in Massachusetts in 2019 dollars, $16,700 per Table 4.

These average recommended comprehensive crash costs are displayed below in Table 4 for the following facility types:

1. Urban Arterial 3-Leg Signalized Intersections (U3SG);
2. Urban Arterial 3-Leg Stop-Control Intersections (U3ST);
3. Urban Arterial 4-Leg Signalized Intersections (U4SG);
4. Urban Arterial 4-Leg Stop-Control Intersections (U4ST);
5. Urban 2 Lane Undivided Arterial Segments;
   a. District 1 (U2UAD1);
   b. District 2 (U2UAD2);
   c. District 3 (U2UAD3);
   d. District 4 (U2UAD4);
   e. District 5 (U2UAD5);
   f. District 6 (U2UAD6);
6. Urban 4 Lane Undivided Arterial Segments (U4UA);
7. Urban 4 Lane Divided Arterial Segments (U4DA); and
8. Rural 2 Lane Undivided Arterial and Collector Segments (R2UAC).

Table 4 - Summary of Recommended Costs for KA, KAB, FI, and Total Crashes by Facility Type

Facility Type[1]	Recommended KA Crash Costs	Recommended KAB Crash Costs	Recommended FI Crash Costs	Recommended Total Crash Costs
U3SG	$2,013,500	$530,600	$339,500	$108,300
U3ST	$1,986,600	$551,200	$352,800	$101,300
U4SG	$1,835,200	$506,900	$327,200	$107,300
U4ST	$1,658,100	$493,500	$319,100	$115,500
U2UAD1	$3,726,100	$803,200	$501,300	$127,700
U2UAD2	$3,306,600	$819,400	$490,700	$145,600
U2UAD3	$3,867,800	$934,000	$532,100	$127,400
U2UAD4	$2,222,900	$648,000	$402,400	$106,800
U2UAD5	$3,114,600	$852,900	$522,500	$151,100
U2UAD6	$2,917,600	$756,400	$462,000	$132,200
U4UA	$3,029,900	$825,100	$481,300	$133,300
U4DA	$3,548,400	$825,600	$530,800	$151,300
R2UAC	$4,705,500	$1,336,400	$878,400	$246,000
All Facilities	$2.764,700	$706,100	$441,000	$121,400

[1]These facility type codes correspond to those in the list prior to the table.

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[6] Previously known as "non-incapacitating injury" crashes.

Average Network Screening Costs

MassDOT uses Equivalent Property Damage Only (EPDO) costs to rank Highway Safety Improvement Program (HSIP) intersection clusters. Like the approach taken to estimate the costs in Table 4, VHB estimated average costs for different severity costs for crashes at intersections. The MassDOT IMPACT Cross-Tabulation tool was used to obtain the distribution of crashes by KABCO severity and Relation to Junction. The analysis included crashes with the following Relation to Junction attributes:

- Five-point or more;
- Four-way intersection;
- T-intersection;
- Traffic circle; and
- Y-intersection.

Table 5 summarizes the average costs and EPDO for different severity categories. EPDO is calculated using Equation 5.

$$EPDO = \frac{\$_{Severity\ Category}}{\$_{PDO}} = \frac{\$_{Severity\ Category}}{\$16,700}$$

Equation 5

Table 5 – Average EPDO for intersection crash severity for use in network screening.

KABCO Severity Combination	Average Crash Cost	EPDO
K+A	$1,992,300	119
B+C	$223,700	13
K+A+B	$554,100	33
C	$179,600	11
K	$16,257,800	974
A+B+C	$272,600	16
K+A+B+C	$352,600	21