Appendix C – Costs, Benefits, and Net Benefits of HOS Rule Components and Sensitivity Analysis for Assumed Percentage of Fatigue Reduction

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Appendix C

1. Costs, Benefits, and Net Benefits of HOS Rule Components for Proposed Option and Sensitivity Analysis for Assumed Percentage of Fatigue Reduction

This Appendix first presents the results of the analysis broken down into the components of Options 2 through 4 under different assumption of baseline fatigue involvement. We present the costs, benefits, and net benefits of the following major components: 10 hours of driving allowed per day, 9 hours of driving allowed per day, the 7-day restart restriction, the 2-night restart provision, and the 30-minute break provision. These estimates are all for each component relative to the current rule. That is, we start with the current rule, add one component, and evaluate the costs and benefits relative to the current rule.

Because the provisions of the proposed rule overlap to some extent (e.g., reducing daily working hours due to the 30-minute break provision is expected to reduce the use of the 11th hour and also reduce weekly working hours), *the sum of the costs and benefits of the individual components does not equal the costs and benefits of the all of the components considered as a package.*

2. Cost of HOS Rule Components for 13 Percent Baseline Fatigue Level

We first present the cost of the HOS rule components assuming a baseline level of 13 percent fatigue involvement in crashes. Following OMB Circular A-4, we present all impacts discounted at both 7 percent and 3 percent. Exhibits C-1 through C-3 present the 10-year impacts discounted at 7 percent, and Exhibits C-4 through C-6 present the impacts discounted at 3 percent. Finally, Exhibits C-7 through C-9 show the annual impacts on which the discounted estimates were based. All dollar figures in the first six exhibits below are present values (2008$) over 10 years, rounded to the nearest $100 million; the dollar figures in Exhibits C-7, C-8, and C-9 are annual, and rounded to the nearest $10 million.

For this analysis we look at 5 separate components that encompass Option 2 through Option 4. Each of these options utilizes some portion of these components, making them unique. All the options incur costs due to the 7-day restart restriction, the 2-night restart provision, and 30-minute break provision. Option 2 imposes a 10-hour limit on driving time. Option 3 and 4 differ from Option 2 only in the amount of driving time allowed within a duty period. Option 3 allows for 11 hours of driving, or 1 hour more than Option 2. Option 4 allows for 9 hours of driving, or 1 hour less than Option 2.

Exhibit C-1 below shows the costs of the components discounted at 7 percent. The largest cost incurred is the 9-hour driving restriction, which is approximately $15.9 billion and only pertains to Option 4. The second largest discounted cost component, applying only to Option 2, is the 10-hour driving restriction, which equals $5.1 billion. The next largest cost component is the 7-day restart restriction, which equals $2.6 billion.

Exhibit C-1. Ten-Year Costs by Rule Component, Discounted at 7 Percent (Millions)
(Excludes approximately $300 million for training and reprogramming)

10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
$5,100	$15,900	$2,600	$400	$700

Exhibit C-2 presents the discounted benefits broken down into the various components. The 9-hour driving restriction is the largest benefit category under all three baseline sleep assumptions.

Exhibit C-2. Ten-Year Benefits of by Rule Component, Discounted at 7 Percent (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$6,500	$15,300	$5,900	$800	$1,700
Medium Sleep	$4,700	$10,300	$4,100	$500	$1,300
High Sleep	$2,800	$5,300	$2,300	$300	$800

Exhibit C-3 displays the discounted net benefits broken down into the various components. When we use the medium baseline sleep assumption, the 7-day restart restriction shows the largest net benefits at $1.5 billion. The second largest net benefits are those resulting from the 30-minute break provision, which amounts to approximately $500 million. Assuming low baseline sleep, the 7-day restart restriction is again the largest net benefit at approximately $6.5 billion. The net benefits become negative for the 9-hour driving restriction under the medium and high baseline sleep scenarios, amounting to negative $5.9 billion and negative $10.9 billion, respectively. In addition, when we use the high baseline sleep assumption, the 10-hour driving restriction results in net benefits of negative $2.3 billion.

Exhibit C-3. Ten-Year Net Benefits by Rule Component, Discounted at 7 Percent (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$1,400	-$900	$3,300	$400	$1,100
Medium Sleep	-$500	-$5,900	$1,500	$200	$500
High Sleep	-$2,300	-$10,900	-$200	-$100	$100

Exhibit C-4 shows the costs of the components discounted at 3 percent. The largest discounted cost is incurred due to the 9-hour driving restriction, which is approximately $18.6 billion. The second largest discounted cost component is the 10-hour driving restriction, which amounts to $6.0 billion.

Exhibit C-4. Ten-Year Costs by Rule Component, Discounted at 3 Percent (Millions)
(Excludes approximately $300 million for training and reprogramming)

10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
$6,000	$18,600	$3,000	$400	$800

Exhibit C-5 presents the discounted benefits of the proposed option broken down into the five components. Using a discount rate of 3 percent, the 9-hour driving restriction results in the largest benefits ($20.9 billion) when we use the low baseline sleep assumption. Under the medium and high baseline sleep assumptions, the 9-hour restriction is still the largest component at approximately $13.0 and $5.1 billion, respectively.

Exhibit C-5. Ten-Year Benefits by Rule Component, Discounted at 3 Percent (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$9,000	$20,900	$8,600	$1,100	$2,500
Medium Sleep	$6,000	$13,000	$5,800	$800	$1,800
High Sleep	$3,100	$5,100	$3,000	$400	$1,000

Exhibit C-6 displays the discounted net benefits broken down into the five components. When we use the medium baseline sleep assumption, the 7-day restart restriction results in the largest net benefits - approximately $2.8 billion. When we use the low baseline sleep assumption, the 7-day restart restriction again shows the largest net benefits at approximately $5.5 billion. Using low baseline sleep, the net benefits for all of the proposed option's components are positive. When we use the high baseline sleep assumption, the 10-hour driving restriction, the 9-hour driving restriction, and the 2-night restart provision result in net benefits equal negative $2.9 billion, negative $13.4 billion, and negative $100 million, respectively. We obtained a similar result for the 9-hour driving restriction using the medium baseline sleep scenario, with net benefits amounting to negative $5.5 billion.

Exhibit C-6. Ten-Year Net Benefits by Rule Component, Discounted at 3 Percent (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$3,000	$2,400	$5,500	$700	$1,700
Medium Sleep	$0	-$5,500	$2,800	$300	$1,000
High Sleep	-$2,900	-$13,400	$0	-$100	$200

To compare these component net benefits across the options, we can sum the individual components of Options 2 through 4. Because all the options include the 7-day restart restriction, the 2-night restart provision, and the 30-minute break provision, we can compare the differences for these options by considering the driving time restrictions alone. Because 11 hours are allowed under the current rule, the benefits for Option 3 represent the base case (i.e., no incremental net benefits beyond the 7-day restart restriction, the 2-night restart provision, and the 30-minute break provision). Option 2 restricts driving time to 10 hours, resulting in

incremental net benefits of $3.0 billion for the low sleep scenario, zero for the medium sleep scenario, and negative $2.9 billion for the high sleep scenario. Finally, for Option 4, we only need to consider the 9-hour driving restriction, thus the incremental net benefits for low, medium and high sleep scenarios are $2.4 billion, negative $5.5 billion, and negative $13.4 billion, respectively.

Exhibits C-7, C-8, and C-9 show the annual costs, benefits, and net benefits of the components. These tables were the basis for the present value estimates presented in the first six exhibits.

Exhibit C-7. Annual Costs by Rule Component (Millions)
(Excludes approximately $40 million for training and reprogramming)

10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
$680	$2,120	$340	$50	$90

Exhibit C-8. Annual Benefits by Rule Component (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
7% Discounting					
Low Sleep	$870	$2,040	$780	$110	$230
Medium Sleep	$620	$1,370	$550	$70	$140
High Sleep	$370	$710	$310	$40	$100
3% Discounting					
Low Sleep	$1,020	$2,380	$980	$130	$290
Medium Sleep	$680	$1,480	$660	$90	$200
High Sleep	$350	$580	$340	$40	$110

Exhibit C-9. Annual Net Benefits by Rule Component (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
7% Discounting					
Low Sleep	$190	-$120	$440	$50	$140
Medium Sleep	-$60	-$780	$200	$20	$70
High Sleep	-$310	-$1,450	-$30	-$10	$10
3% Discounting					
Low Sleep	$340	$270	$630	$80	$190
Medium Sleep	$0	-$630	$320	$30	$110
High Sleep	-$330	-$1530	$0	-$10	$20

Next, we present the results of the analysis broken down into components and estimated using alternative assumptions for the baseline percentage of crashes due to fatigue (7 and 18 percent baseline fatigue levels). We present the costs, benefits, and net benefits of the options for the same major components as shown above. We again present these estimates for each component relative to the current rule.

Exhibits C-10 through C-18 present the impacts estimated using the 7 percent fatigue-related crashes assumptions. Exhibits C-10 through C-12 present the impacts discounted at 7 percent, Exhibits C-13 through C-15 present the impacts discounted at 3 percent, and Exhibits C-16 through C-18 show the annual impacts on which the discounted estimates were based.

Exhibits C-19 through C-24 present the impacts estimated using the 18 percent fatigue-related crashes assumption. Exhibits C-19 and C-20 present the impacts discounted at 7 percent, Exhibits C-21 and C-22 present the impacts discounted at 3 percent, and Exhibits C-23 and C-24 show the annual impacts on which the discounted estimates were based.

All dollar figures in Exhibits C-10 through C-15 and Exhibits C-19 through C-22 are present values (2008$) over 10 years, rounded to the nearest $100 million; the dollar figures in Exhibits C-16 through C-18 and C-23 and C-24 are annual and rounded to the nearest $10 million.

The cost of each component is not a function of the percent of fatigue-related crashes so we repeat our presentation of the cost estimates only once for brevity. Exhibit C-10 presents the costs discounted at 7 percent, Exhibit C-13 presents the costs discounted at 3 percent, and Exhibit C-16 presents the annual costs on which the discounted estimates were based.

3. Cost of HOS Rule Components for 7 Percent Baseline Fatigue Level

Exhibit C-10. Costs by Rule Component, Discounted at 7 Percent (Millions)
(Excludes approximately $300 million for training and reprogramming)

10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
$5,100	$15,900	$2,600	$400	$700

Exhibit C-11. Benefits by Rule Component – Using 7 Percent Fatigue, Discounted at 7 Percent (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$5,000	$11,600	$5,100	$700	$1,500
Medium Sleep	$3,200	$6,600	$3,300	$500	$1,000
High Sleep	$1,300	$1,700	$1,600	$200	$500

Exhibit C-12. Net Benefits by Rule Component – Using 7 Percent Fatigue, Discounted at 7 Percent (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	-$100	$4,600	$2,300	$300	$800
Medium Sleep	-$2,000	-$9,600	$800	$100	$200
High Sleep	-$3,800	-$14,600	-$1,100	-$200	-$200

Exhibit C-13. Costs by Rule Component, Discounted at 3 Percent (Millions)
(Excludes approximately $300 million for training and reprogramming)

10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
$6,000	$18,600	$3,000	$400	$800

Exhibit C-14. Benefits by Rule Component – Using 7 Percent Fatigue, Discounted at 3 Percent (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$7,300	$16,600	$7,600	$1,000	$2,200
Medium Sleep	$4,300	$8,700	$4,800	$600	$1,500
High Sleep	$1,300	$800	$2,000	$300	$700

Exhibit C-15. Net Benefits by Rule Component – Using 7 Percent Fatigue, Discounted at 3 Percent (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$1,300	-$2,000	$4,700	$500	$1,400
Medium Sleep	-$1,700	-$9,800	$1,800	$200	$600
High Sleep	-$4,700	-$17,700	-$100	-$200	-$200

Exhibit C-16. Annual Costs by Rule Component (Millions)

(Excludes approximately $40 million for training and reprogramming)

10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
$680	$2,120	$340	$50	$90

Exhibit C-17. Annual Benefits by Rule Component – Using 7 Percent Fatigue (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
7% Discounting					
Low Sleep	$670	$1,550	$680	$90	$200
Medium Sleep	$420	$880	$440	$60	$130
High Sleep	$170	$220	$210	$20	$70
3% Discounting					
Low Sleep	$830	$1,890	$870	$110	$250
Medium Sleep	$490	$990	$550	$70	$170
High Sleep	$150	$90	$230	$30	$80

Exhibit C-18. Annual Net Benefits of by Rule Component – Using 7 Percent Fatigue (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
7% Discounting					
Low Sleep	-$10	-$610	$300	$40	$100
Medium Sleep	-$260	-$1,280	$100	$10	$40
High Sleep	-$560	-$1,940	-$140	-$30	-$30
3% Discounting					
Low Sleep	$150	-$230	$530	$60	$160
Medium Sleep	-$190	-$1,120	$210	$20	$70
High Sleep	-$530	-$2,020	-$110	-$20	-$20

4. Cost of HOS Rule Components for 18 Percent Baseline Fatigue Level

Exhibit C-19. Benefits by Rule Component – Using 18 Percent Fatigue, Discounted at 7 Percent (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$770	$18,400	$6,500	$900	$2,000
Medium Sleep	$590	$13,400	$4,700	$700	$1,400
High Sleep	$400	$8,400	$3,000	$400	$1,000

Exhibit C-20. Net Benefits by Rule Component – Using 18 Percent Fatigue, Discounted at 7 Percent (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$2,600	$2,200	$4,000	$500	$1,200
Medium Sleep	$800	-$2,900	$2,200	$300	$800
High Sleep	-$1,100	-$7,800	$500	$0	$300

158 **Exhibit C-21. Benefits by Rule Component – Using 18 Percent Fatigue, Discounted at 3 Percent**
159 **(Millions)**

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$8,900	$12,000	$8,000	$1,100	$2,300
Medium Sleep	$6,400	$14,200	$5,600	$800	$1,700
High Sleep	$3,800	$7,400	$3,200	$500	$1,100

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161 **Exhibit C-22. Net Benefits by Rule Component – Using 18 Percent Fatigue, Discounted at 3**
162 **Percent (Millions)**

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
Low Sleep	$3,800	$500	$5,400	$700	$1,700
Medium Sleep	$1,300	-$1,700	$3,000	$400	$1,000
High Sleep	-$3,100	-$8,400	$700	$0	$400

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164 **Exhibit C-23. Annual Benefits by Rule Component – Using 18 Percent Fatigue (Millions)**

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
7% Discounting					
Low Sleep	$1,030	$2,450	$870	$120	$260
Medium Sleep	$780	$1,780	$630	$90	$190
High Sleep	$530	$1,120	$400	$50	$130
3% Discounting					
Low Sleep	$1,180	$2,797	$1,060	$140	$130
Medium Sleep	$850	$1,890	$750	$100	$230
High Sleep	$510	$990	$430	$60	$140

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Exhibit C-24. Net Benefits by Rule Component – Using 18 Percent Fatigue (Millions)

	10-Hour Driving Restriction	9-Hour Driving Restriction	7-Day Restart Restriction	2-Night Restart Provision	30-Minute Break Provision
7% Discounting					
Low Sleep	$350	$290	$530	$70	$160
Medium Sleep	$100	-$380	$290	$40	$100
High Sleep	-$150	-$1,040	$60	$0	$40
3% Discounting					
Low Sleep	$500	$670	$720	$90	$220
Medium Sleep	$170	-$220	$400	$50	$130
High Sleep	-$170	-$1120	$90	$0	$50

5. Rule Components, Packages, and Interaction Effects

Exhibit C-25 extends the single component analysis and compares the individual component costs, benefits, and net benefits for the 7-day restart provision, the 2-night restart provision, and the 30-minute break provision independently, for packages of two of the three provisions, and for all three provisions. First, we considered the selected provisions separately with no overlapping effects. Next, we considered the provisions in packages of two, including overlapping effects. Finally, we compared the two methods to estimate the interaction effect of each grouping of the rule components. We round the values in Exhibit C-25 to the nearest million to demonstrate the similarity in net benefits for some of these alternatives.

Option 3, with all three provisions analyzed as a package, is shown to have net benefits of $205 million. That package with the 2 night provision removed (that is, including only the 7 day restart provision and the 30 minute break) appears to have marginally greater net benefits, at $206 million. Not shown in the table, however, are the substantial unmonetized benefits the 2 night provision is expected to have due to the circadian advantages of nighttime sleep. As noted in Section 6.4 of the this document, these additional benefits were too complex to be quantified and monetized reliably. They would almost certainly be large enough, though, to ensure that the net benefits of the rule are improved by the inclusion of the 2 night provision. Similarly, the net benefits of a package that excluded the 30 minute break provision appears to be slightly greater than the net benefits of the Option 3 package, at $206 million. Again, the 30 minute break provision is expected to provide very substantial crash reduction benefits that could not be included in the analysis. These benefits, as noted in Section 6.4, are related to the short-term reductions in crashes provided by the break's restorative effects on alertness. If these short-term benefits could be monetized and added to the break's effects on cumulative fatigue, they would almost certainly show it to be a cost-beneficial addition to the rule.

Exhibit C-25. Component and Interaction Costs, Benefits and Net Benefits (Millions 2008$)

Change from Current Rule Baseline	Costs	Safety Benefits (13 Percent Fatigue)	Health Benefits (Medium Sleep Level, 7 Percent Discounting)	Net Benefits*
7-day restart alone	$342	$227	$318	$204
2-night restart alone	$51	$35	$38	$22
30-minute break alone	$94	$72	$94	$72
Sum of Option 3 provisions, taken separately	$487	$334	$450	$297
Option 3 analyzed as a package	$426	$282	$349	$205
Overlap among Option 3 provisions (difference between sum of separate provisions and package)	$62	$52	$102	$92
Sum of 7 day and 2 night provisions, taken separately	$393	$262	$356	$225
7 day and 2 night provisions, analyzed as a package	$393	$260	$340	$206
Overlap between 7 day and 2 night provisions (difference between sum of separate provisions and package)	$0	$2	$17	$19
Sum of 7 day and 30 minute provisions, taken separately	$436	$299	$412	$276
7 day and 30 minute provisions, analyzed as a package	$374	$253	$328	$206
Overlap between 7 day and 30 minute provisions (difference between sum of separate provisions and package)	$62	$47	$84	$69
Sum of 2 night and 30 minute provisions, taken separately	$145	$107	$132	$94
2 night and 30 minute provisions, analyzed as a package	$145	$95	$127	$76
Overlap between 2 night and 30 minute provisions (difference between sum of separate provisions and package)	$0	$12	$5	$17

* Does not include the $40 million in reprogramming costs.
Note: Totals do not add due to rounding.

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