Appendix G: Benefit-Cost Assumptions and Methodology
US 360/ROUTE 288 INTERCHANGE AREA STUDY – BENEFIT-COST ASSUMPTIONS AND METHODOLOGY

Assumptions

Analysis Timeframe

- Construction Year = 2021
- Analysis Period = 20 years, 365 days/year

Value of Time

Value of time was calculated to convert time savings to a monetary value. Value of time was calculated separately for autos and trucks.

Autos

The value of time for autos was calculated as the sum of the value of travel time and the value of time-related depreciation.

Value of Travel Time

- MEDIAN HOUSEHOLD INCOME
  
  Source: http://quickfacts.census.gov
  - Chesterfield County: $72,363
  - City of Richmond: $39,445
  - Powhatan County: $76,495
  - City of Colonial Heights: $51,612
  - City of Petersburg: $35,126
  - Average of Chesterfield County and Surrounding Counties: $55,008

- MEDIAN WAGE RATES
  
  Source: http://www.bls.gov
  - Richmond: $17.38

- REASON FOR TRAVEL
  
  Source: http://nhts.ornl.gov/tables09/ae/work/Job34866.html
  - Personal Travel: 93.7%
  - Business Travel: 6.3%

- EMPLOYER COSTS FOR EMPLOYEE COMPENSATION
  
  Source: http://stats.bls.gov/news.release/ecenr.releases.0.htm
  - Wages: 68.7%
  - Benefits: 31.3%

- VALUE OF TRAVEL TIME (PER HOUR)
  
  Source: http://www.dot.gov/sites/dot.gov/files/docs/vot_guidance_092811c_0.pdf
  - Personal Travel: Median Household Income × 50%
  - Personal Travel: $13.22/hr

- VALUE OF TRAVEL TIME (PER HOUR)

  Source: http://www.dot.gov/sites/dot.gov/files/docs/vot_guidance_092811c_0.pdf
  - Personal Travel: $13.22/hr

- BUSINESS TRAVEL = MEDIAN WAGE RATE × (1 + % Benefits of Employer Costs for Employee Compensation) × % Wages of Employer Costs for Employee Compensation

- BUSINESS TRAVEL: $25.30/hr

- COMBINATION PERSONAL AND BUSINESS TRAVEL

  = (Personal Travel × % Personal Travel) + (Business Travel × % Business Travel)

- COMBINATION PERSONAL AND BUSINESS TRAVEL: $22.80 (rounded to the nearest $0.05)

Value of Time-Related Depreciation

- TIME-RELATED DEPRECIATION (1995)
  
  - Passenger Cars (1995): 134.1
  - Trucks with GVW < 14,000 lb (1995): 159.0

- TIME-RELATED DEPRECIATION (Sep 2014)
  
  Source: http://www.bls.gov/web/ppi/ppitable09.pdf
  - Passenger Cars (2014): 129.3
  - Trucks with GVW < 14,000 lb (2014): 163.3

- TIME-RELATED DEPRECIATION (2014)

  - Time-Related Depreciation (2014): $1.45 (rounded to the nearest $0.05)

Auto Value of Time

Auto Value of Time = Value of Travel Time + Time-Related Depreciation

Auto Value of Time: $24.25

Trucks

The value of time for trucks was calculated as the sum of the value of travel time, the value of time-related depreciation, and the value of freight inventory delay.

Value of Travel Time

- MEDIAN WAGE RATES
  
  Source: http://www.bls.gov/oes/current/oes_va.htm#53-0000
  - Virginia (Heavy and Tractor-Trailer Truck Drivers): $17.58
  - Virginia (Light Truck or Delivery Services Drivers): $14.34
  - Virginia Average: $15.96
**VALUE OF TRAVEL TIME (PER HOUR)**

- Value of Travel Time = Median Wage Rate \times (1 + \% Benefits of Employer Costs for Employee Compensation)
- Value of Travel Time: $24.20 (rounded to the nearest $0.05)

**Value of Time-Related Depreciation**

- **TIME-RELATED DEPRECIATION (1995)**
  - Six-tire trucks (1995): $2.65/hr
  - 3+ axles combination trucks (1995): $7.16/hr
  - 3 or 4 axles (1995): $6.41/hr
  - 5+ axles (1995): $6.16/hr
  - Average truck (1995): $6.60/hr (rounded to the nearest $0.05)

- **TIME-RELATED DEPRECIATION (2014)**
  - Truck Scaled Depreciation (1995-2014)= Average 2014 Trucks GVW > 14,000 lb PPI / 1995 Trucks GVW > 14,000 lb PPI
  - Time-Related Depreciation (2014): $8.45 (rounded to the nearest $0.05)

**Value of Freight Inventory Delay**

- **AVERAGE VALUE OF FREIGHT INVENTORY DELAY (PER HOUR)**
  - Average Value of Freight Inventory Delay: $0.25/hr (rounded to the nearest $0.05)

**Repair Cost**

- **COSTS PER CRASH**
  - Crash Type | 2014 | 2021*
  - --- | ---- | ----
  - Fatal Crash | $5,000,000 | $6,100,000
  - Injury Crash (Type A) | $275,000 | $340,000
  - Injury Crash (Type B) | $98,000 | $120,000
  - Injury Crash (Type C) | $55,000 | $70,000
  - Injury Crash (Average) | $142,667 | $180,000
  - PDO Crash | $9,000 | $10,000

  * 2021 costs are calculated using 2014 cost and a 3% annual inflation rate

**Occupancy Rate**

- Occupancy rates were used to account for multiple passengers in a vehicle.

**Crystal Run**

- (Source: http://www.bls.gov/esi/esi2013/esi2013_325.pdf)

**Crash Reduction Factors (CRF)**

- Crash Reduction Factors (CRFs) were used to determine the reduction in crashes after an improvement is implemented.

- **CRASH REDUCTION FACTOR**
  - (Source: FHWA's Desktop Reference for Crash Reduction Factors)
    - Convert signalized intersection to displaced left-turn (DLT) intersection CRF: 19 (all crash types, fatal and injury crashes)
    - Convert signalized intersection to a signalized superstreet configuration CRF: 56 (all crash types, all crash severities)
    - Convert signalized intersection to a continuous green T-intersection (CGT) CRF: 97 (angle crashes, all severities)
    - Increase number of lanes CRF: 31 (all crash types, all crash severities)
    - Change number of lanes on freeway exit ramp from 1 to 2 CRF: 42 (all crash types, all crash severities)
    - Convert at-grade intersection into grade-separated interchange CRF: 42 (all crash types, all crash severities)
    - Provide straight ramp instead of cloverleaf ramp CRF: 45 (all crash types, all crash severities)
    - Provide an auxiliary lane between an entrance ramp and exit ramp CRF: 20 (all crash types, all crash severities)
Methodology
The following sections outline the equations used to calculate the benefit-cost (B/C) for each improvement concept:

Operational Benefit

\[
\text{Operational Benefit} = \sum_{\text{Year}=2020}^{2040} \Delta \text{Truck Delay}_{\text{Year}} \times \text{Truck Value of Time} + \Delta \text{Auto Delay}_{\text{Year}} \times \text{Auto Value of Time}
\]

\[
\Delta \text{Truck Delay} = (\text{No Build AM Travel Time} \times \text{No Build AM Trucks} - \text{Build AM Travel Time} \times \text{Build AM Trucks}) + (\text{No Build PM Travel Time} \times \text{No Build PM Trucks} - \text{Build PM Travel Time} \times \text{Build PM Trucks}) \times \frac{365 \text{ days}}{1 \text{ year}} \times \frac{1 \text{ hr}}{3600 \text{ sec}} \times (\text{Truck Occupancy Rate})
\]

\[
\Delta \text{Auto Delay} = (\text{No Build AM Travel Time} \times \text{No Build AM Autos} - \text{Build AM Travel Time} \times \text{Build AM Autos}) + (\text{No Build PM Travel Time} \times \text{No Build PM Autos} - \text{Build PM Travel Time} \times \text{Build PM Autos}) \times \frac{365 \text{ days}}{1 \text{ year}} \times \frac{1 \text{ hr}}{3600 \text{ sec}} \times (\text{Auto Occupancy Rate})
\]

Safety Benefit

\[
\text{Safety Benefit} = \sum_{\text{Year}=2020}^{2040} \Delta \text{Fatal}_x \text{Fatal Cost} + \Delta \text{Injuries}_x \text{Injury Cost} + \Delta \text{PDOs}_x \text{PDO Cost}
\]

\[
\Delta \text{Fatal} = \text{No Build Fatal Crashes} \times \frac{\text{Fatal CRF}}{100}
\]

\[
\Delta \text{Injuries} = \text{No Build Injury Crashes} \times \frac{\text{Injury CRF}}{100}
\]

\[
\Delta \text{PDO} = \text{No Build PDO Crashes} \times \frac{\text{PDO CRF}}{100}
\]

Total Cost

\[
\text{Total Cost} = \text{Construction Cost} + \text{PE Cost} + \text{ROW Cost} + \sum_{\text{Year}=2020}^{2040} \text{Maintenance cost}_{\text{Year}}
\]

Benefit-Cost

\[
\text{Benefit/Cost} = \frac{\text{Operational Benefit} + \text{Safety Benefit}}{\text{Total Cost}}
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<td>1   US 360 at Old Hundred Road/Commonwealth Centre Parkway</td>
<td>$156,732,307</td>
<td>$9,798,213</td>
<td>$166,530,520</td>
<td>$75,100,000</td>
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<td>2   US 360 at Old Hundred Road/Commonwealth Centre Parkway - Grade-Deparated</td>
<td>$227,745,761</td>
<td>$21,659,208</td>
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<td>$111,900,000</td>
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<td>3   SB Route 288 to WB US 360 Off-Ramp Improvements</td>
<td>$88,501,515</td>
<td>$19,758,213</td>
<td>$108,259,727</td>
<td>$11,600,000</td>
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<td>4   Bailey Bridge Connector Improvements</td>
<td>$441,435,051.59</td>
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<td>5   US 360 Superstreets - 5 Intersections</td>
<td>$333,282,491</td>
<td>$15,273,758</td>
<td>$348,556,249</td>
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<td>6   US 360 at Brad McNeer Parkway - Continuous Green T-Intersection</td>
<td>$57,196,773</td>
<td>$3,820,987</td>
<td>$61,017,760</td>
<td>$9,300,000</td>
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<td>7   Widen NB and SB Route 288 - from 4 Lanes to 6 Lanes</td>
<td>$135,259,458</td>
<td>$45,309,087</td>
<td>$180,568,545</td>
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<td>8   SB Route 288 Construct CD Road (2 Lanes)</td>
<td>$95,576,659</td>
<td>$6,220,154</td>
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<td>9   EB US 360 to NB Route 288 Directional On-Ramp (2 Lanes)</td>
<td>$9,114,190</td>
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