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# ***Overview of Performance Measures: Travel Time Reliability (NHPP), Truck Travel Time Reliability (NHFP) Annual Hours of Peak Hour Excessive Delay (CMAQ), and Non-SOV Travel***

Salt Lake, City, Utah

November 7. 2017



U.S. Department of Transportation  
Federal Highway Administration



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# ***National Performance Management Measures***

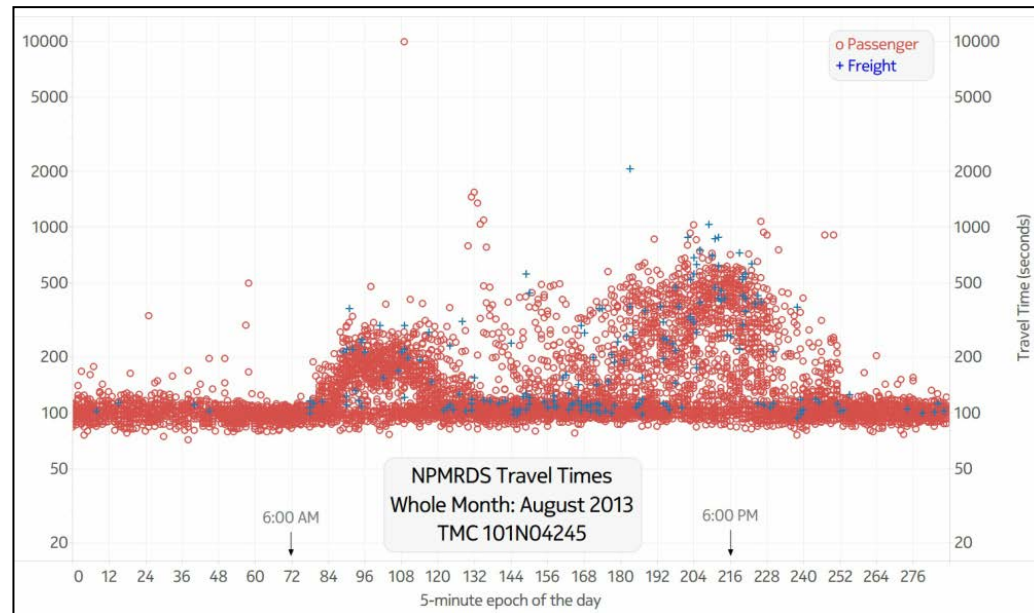
## ***23 CFR Part 490 Subparts E, F, G***

- Subpart E: Measures to Assess the Performance of the National Highway System (NHS)
  - Percent of the Person-Miles Traveled on the Interstate That Are Reliable
  - Percent of the Person-Miles Traveled on the Non-Interstate NHS That Are Reliable
- Subpart F: Measure to Assess Freight Movement on the Interstate
  - TTTR index for the Interstate System
- Subpart G: Measure to Carry Out the Congestion Mitigation and Air Quality Improvement (CMAQ) Program
  - Annual Hours of Peak Hour Excessive Delay Per Capita (PHED)



# NPMRDS

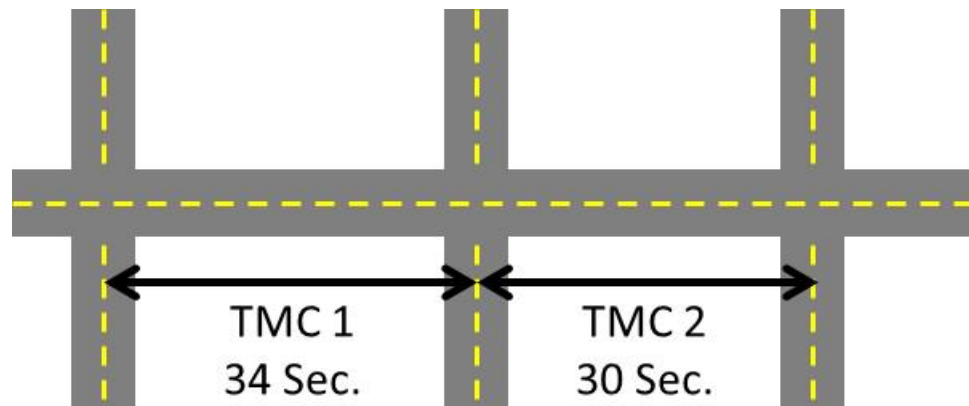
- Travel times provided by road segments
- Pre-defined road segments are called TMC (traffic message channel) codes and based on the industry standard for traffic reporting
- Travel times provided for passenger, freight, combined values



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# ***NPMRDS***

- Map (Shapefile): Contains precise road geometry of the NHS and attributes about the road segment
- TMC Static File: Contains descriptive information about the road segment (TMC code, names, admin info, segment lengths, latitude/longitude)
- Monthly Travel Time Data File: Contains the travel time data for each day for a 1-month timeframe



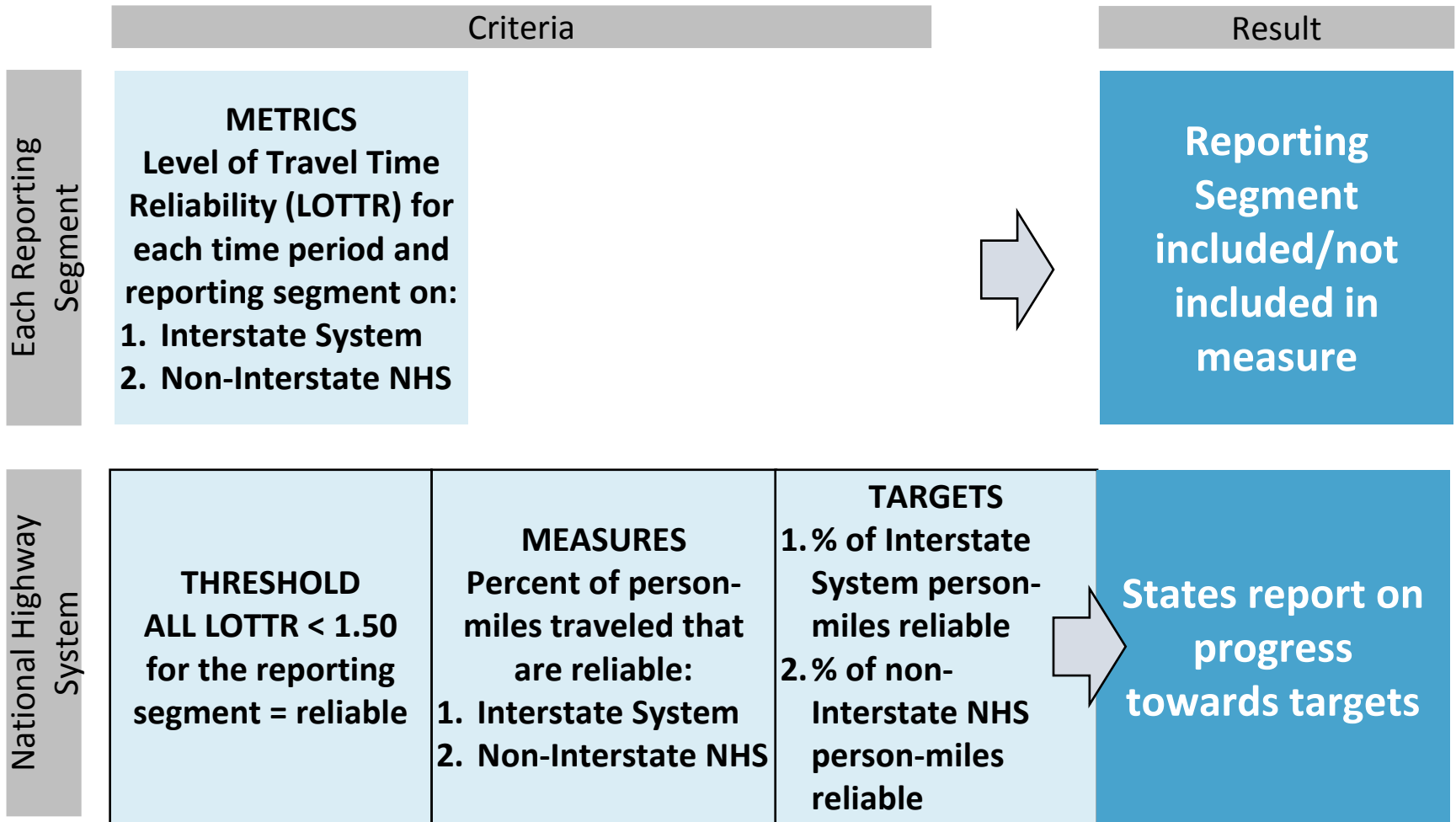
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## ***Definitions***

- *Travel time reliability*: the consistency or dependability of travel times from day to day or across different times of the day



# § 490.507 Travel Time Reliability Measures



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## *Required Data for Reliability Measures*

- Travel time segment length
- Epoch (time interval, i.e., 15-minutes)
- Travel time: all vehicles
- Highway type (Interstate and non-Interstate NHS)



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## *Required Data for Reliability Measures*

- Metropolitan Planning Area boundary designation (for MPO reporting)
- AADT for each segment (HPMS)
- Average vehicle occupancy for all vehicles by specified area (provided by FHWA or locally derived)





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## ***MPO Planning and Urbanized Boundaries***

- For the Reliability measures, the Metropolitan Planning Area boundary is used
- For the PHED measure, the adjusted Census urbanized area boundary is used
- Agencies need to identify travel time segments within these boundaries



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## ***Level of Travel Time Reliability (LOTTTR) Metrics***

- Calculated for each reporting segment
- Calculated for each of 4 time periods for the entire year (nearest hundredth)

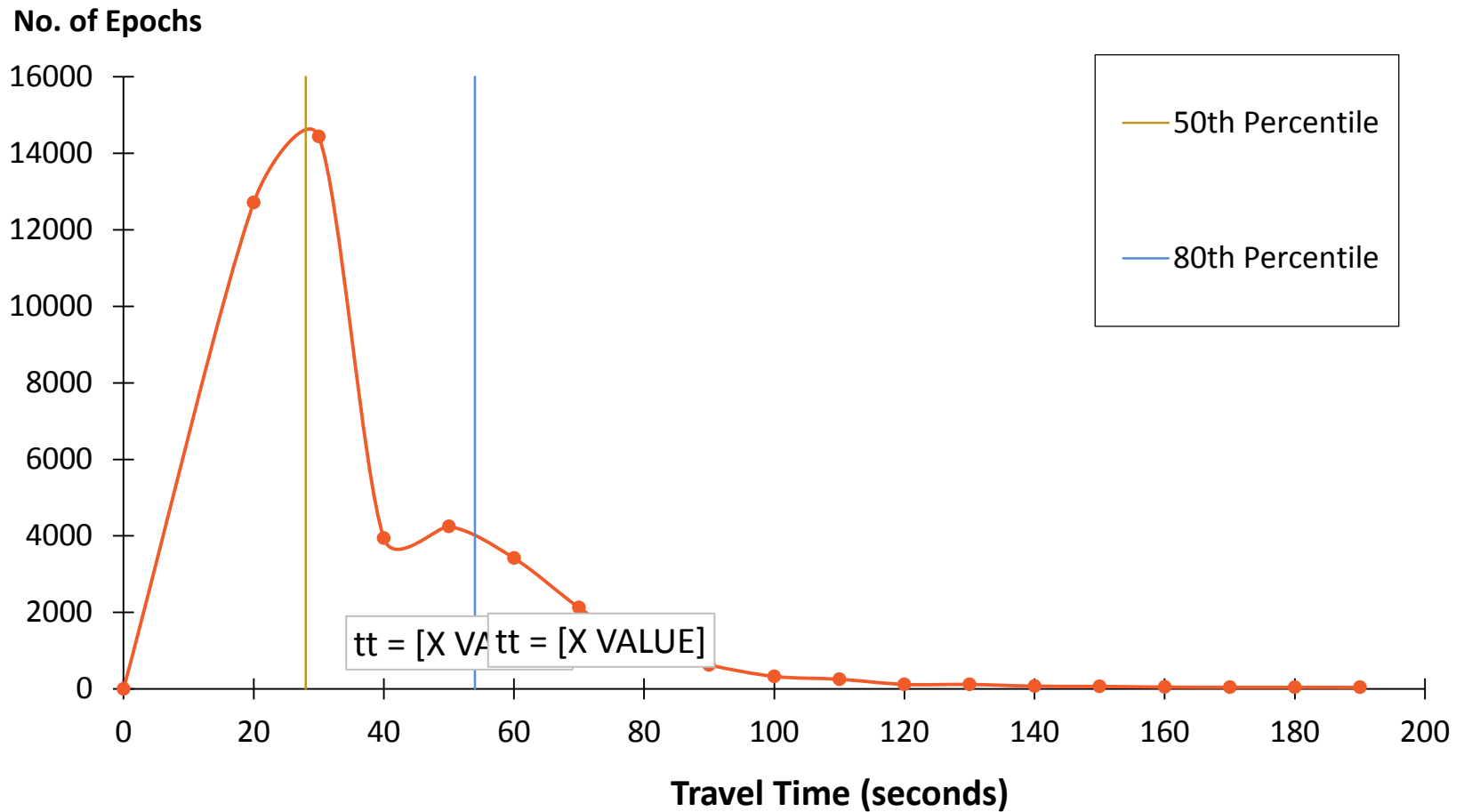
$$LOTTTR_i = \frac{80th\ Percentile\ Travel\ Time_i}{50th\ Percentile\ Travel\ Time_i}$$

Where  $i$  is the time period:

1. 6 a.m. – 10 a.m., weekdays
2. 10 a.m. – 4 p.m., weekdays
3. 4 p.m. – 8 p.m., weekdays
4. 6 am. – 8 p.m., weekends



# LOTTR Example: Select the 80<sup>th</sup> and 50<sup>th</sup> percentile travel times



# LOTTR Example: Metric

$$\frac{\text{Longer Travel Time (80th)}}{\text{Normal Travel Time (50th)}} = \frac{\# \text{ seconds}}{\# \text{ seconds}} = \text{Level of Travel Time Reliability Ratio}$$

## Level of Travel Time Reliability (LOTTR)

*(Single Segment, Interstate Highway System)*

Monday – Friday	6am – 10am	LOTTR = $\frac{44 \text{ sec}}{35 \text{ sec}} = 1.26$
	10am – 4pm	LOTTR = 1.39
	4pm – 8pm	LOTTR = <b>1.54</b>
Weekends	6am – 8pm	LOTTR = 1.31
Must exhibit LOTTR below 1.50 during <b>all</b> of the time periods		<b>Segment IS NOT reliable</b>



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## ***Interstate and Non-Interstate NHS Travel Time Reliability Measures (TTRM)***

- System measure is computed from the reporting segment level LOTTR-values
  - One measure is Interstate reporting segments
  - One measure is Non-Interstate NHS reporting segments
- Ratio of person-miles of travel that are reliable to total person-miles of travel
- A segment is reliable if *all four* LOTTR metrics are  $< 1.50$
- Reported to the nearest 0.1%



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# TTRM

$$TTRM = \frac{\sum_{r=1}^R SL_i \times AV_i \times OF_j}{\sum_{t=1}^T SL_i \times AV_i \times OF_j}$$

$SL_i$  = the segment length of Interstate or Non-IS NHS reporting segment  $i$

$AV_i$  = annual traffic volume of reporting segment  $i$

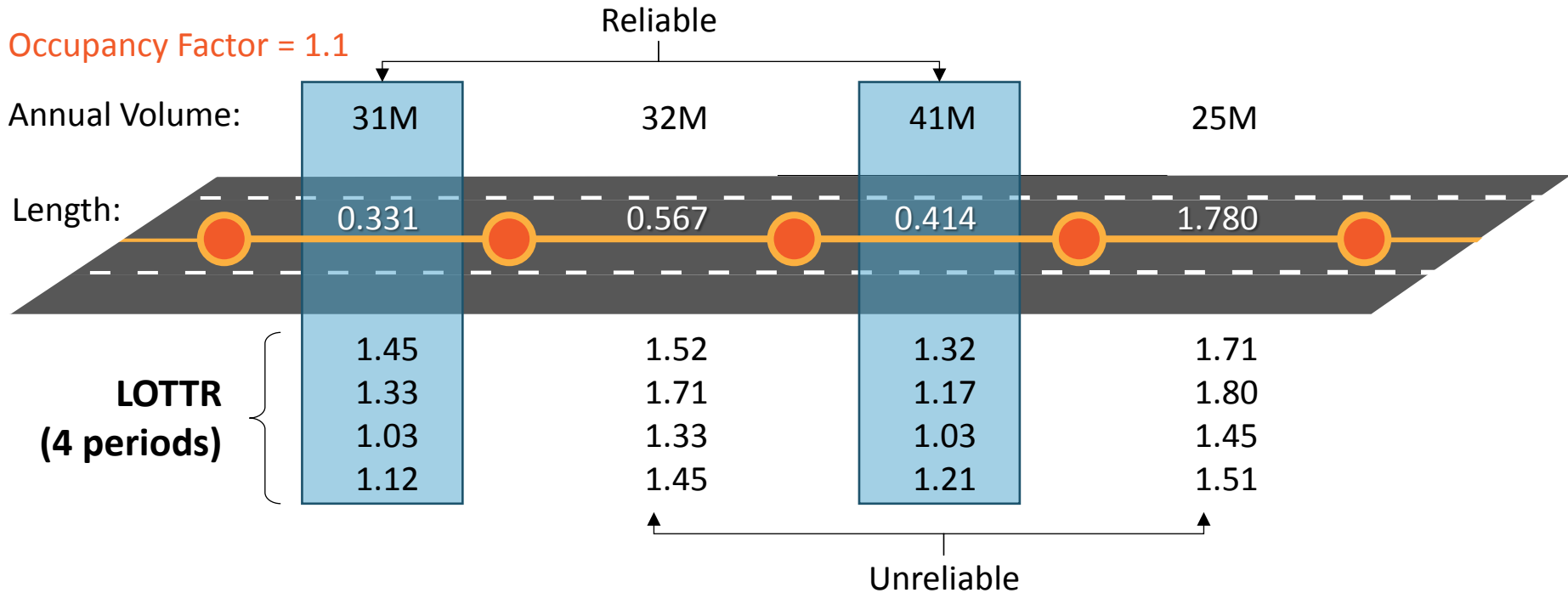
=  $AADT \times Directional Factor \times 365$  (366 for leap yr)

$Directional Factor$  = factor for splitting AADT by direction (default = 0.5)

$OF_j$  = occupancy factor for vehicles on the NHS within a specified geographic area  $j$  within the State/Metropolitan planning area



# Reliability Measure: Complete Example



$$\begin{aligned}
 \text{Travel Time Reliability Measure} &= \frac{(0.331 \times 31 \times 1.1) + (0.414 \times 41 \times 1.1)}{(0.331 \times 31 \times 1.1) + (0.567 \times 32 \times 1.1) + (0.414 \times 41 \times 1.1) + (1.780 \times 25 \times 1.1)} \\
 &= \frac{11.287 + 18.671}{11.287 + 19,958 + 18.671 + 48.950} \\
 &= \frac{29.958}{98.866} \\
 &= 30.3\%
 \end{aligned}$$



# Calculation Sheet (LOTTTRs) –

Segment	Time Period	LOTTTR	Rel.? y/n**	Segment	Time Period	LOTTTR	Rel.? y/n**
1	6-10am	1.62		5	6-10am		
	10-4	1.22			10-4		
	4-8pm	1.33			4-8pm		
	Weekend	1.22			Weekend		
2	6-10am			6	6-10am		
	10-4				10-4		
	4-8pm				4-8pm		
	Weekend				Weekend		
3	6-10am			7	6-10am	1.25	
	10-4				10-4	1.27	
	4-8pm				4-8pm	1.49	
	Weekend				Weekend	1.25	
4	6-10am	1.49		8	6-10am	1.28	
	10-4	1.10			10-4	1.28	
	4-8pm	1.25			4-8pm	1.50	
	Weekend	1.10			Weekend	1.24	





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## ***23 CFR Part 490 Subpart F Measure***

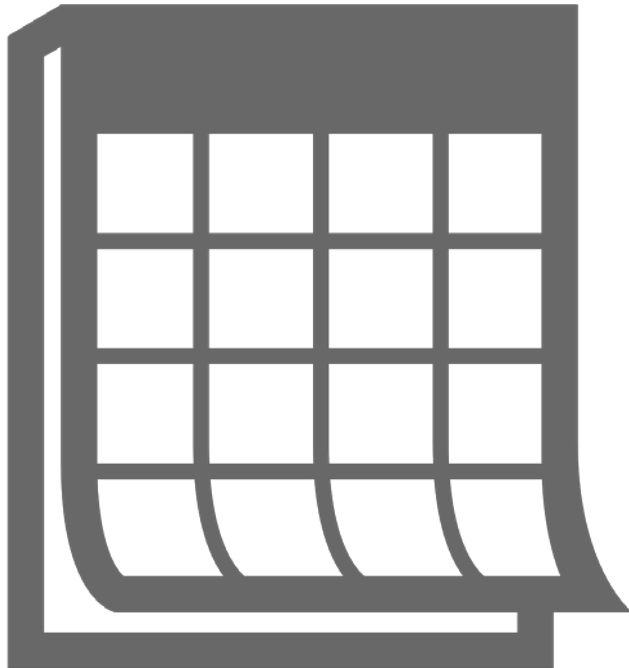
- **Freight Reliability Measure: Truck Travel Time Reliability (TTTR) Index**
  - The sum of maximum TTTR for each reporting segment, divided by the total Interstate system miles



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# ***23 CFR 490.609 Data Requirements: Applicable Time Periods***

Full Year (Jan 1-Dec 31)



Weekdays (Mon – Fri)

**6 – 10 a.m.**

**10 a.m. – 4 p.m.**

**4 – 8 p.m.**

Overnight (all days)

**8 p.m. – 6 a.m.**

Weekends

**6 a.m. –  
8 p.m.**



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## ***Truck Travel Time Reliability (TTTR) Metrics***

- Computed for each time period for the entire year ***for Interstate segments only***, rounded to nearest hundredth

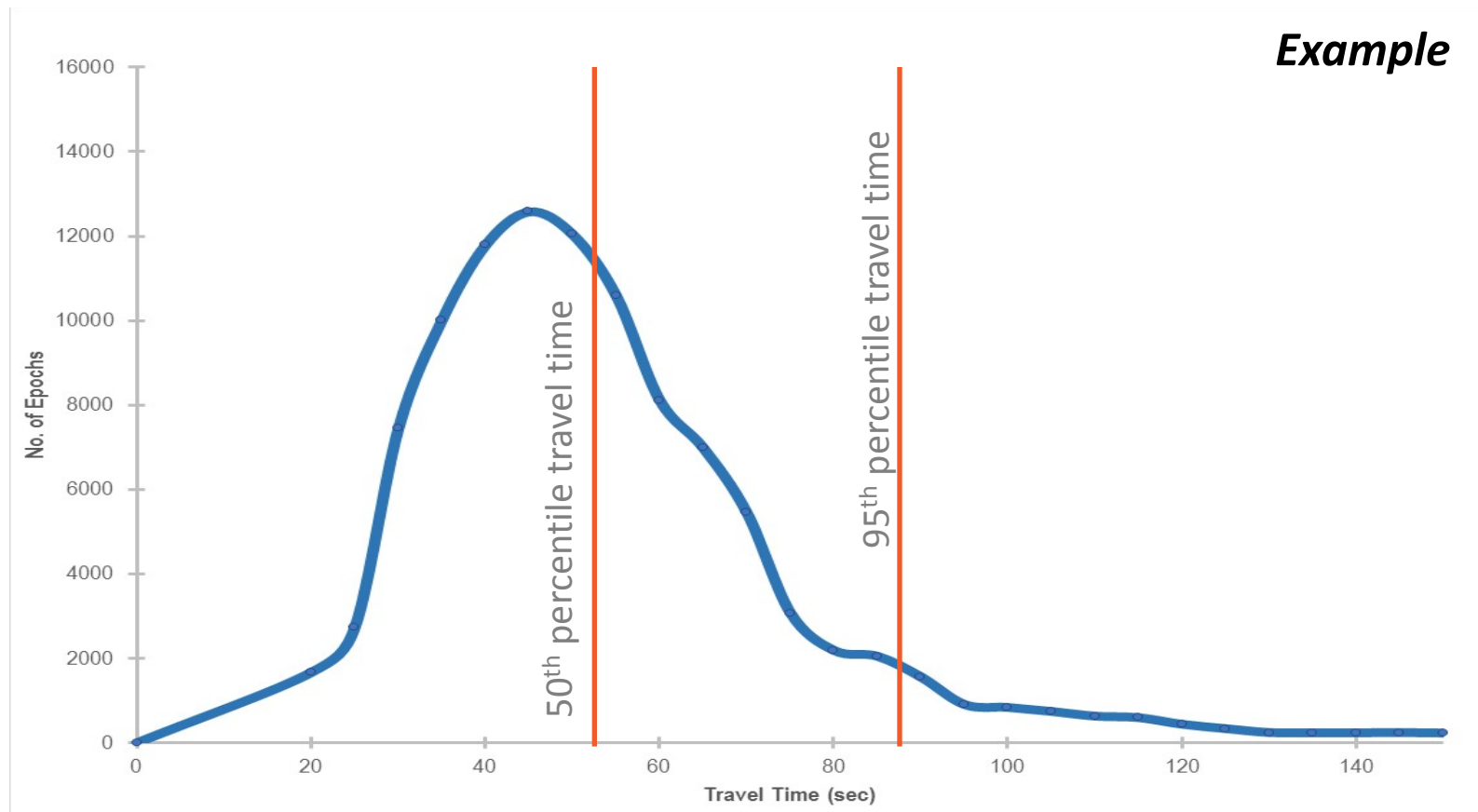
$$TTTR_i = \frac{95th\ Percentile\ Travel\ Time_i}{50th\ Percentile\ Travel\ Time_i}$$

Where  $i$  is the time period:

1. 6 a.m. – 10 a.m. weekdays
2. 10 a.m. – 4 p.m. weekdays
3. 4 p.m. – 8 p.m. weekdays
4. 8 p.m. – 6 a.m. all days
5. 6 a.m. – 8 p.m. weekends



# ***TTTR: Select the 95<sup>th</sup> and 50<sup>th</sup> percentile travel times from the complete distribution***



## 23 CFR 490.611 Freight Reliability Metric

$$\frac{\text{Longer Truck Travel Time (95th)}}{\text{Normal Truck Travel Time (50th)}} = \frac{\# \text{ seconds}}{\# \text{ seconds}} = \text{TTTR Ratio}$$

TTTR: Single Segment, Interstate Highway System		Example
Monday – Friday	6 – 10 a.m.	$\text{TTTR} = \frac{63 \text{ sec}}{42 \text{ sec}} = 1.50$
	10 a.m. – 4 p.m.	$\text{TTTR} = \frac{62 \text{ sec}}{45 \text{ sec}} = 1.38$
	4 – 8 p.m.	$\text{TTTR} = \frac{85 \text{ sec}}{50 \text{ sec}} = \mathbf{1.70}$
Weekends	6 a.m. – 8 p.m.	$\text{TTTR} = \frac{52 \text{ sec}}{40 \text{ sec}} = 1.30$
Overnight	8 p.m. – 6 a.m.	$\text{TTTR} = \frac{46 \text{ sec}}{38 \text{ sec}} = 1.21$
Maximum TTTR		<b>1.70</b>



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## ***Freight Reliability Measure***

$$\begin{aligned} & \textit{Freight Reliability} \\ &= \frac{\sum_{i=1}^T (SL_i \times \textit{maxTTTR}_i)}{\sum_{i=1}^T (SL_i)} \end{aligned}$$

$i$  = an Interstate reporting segment

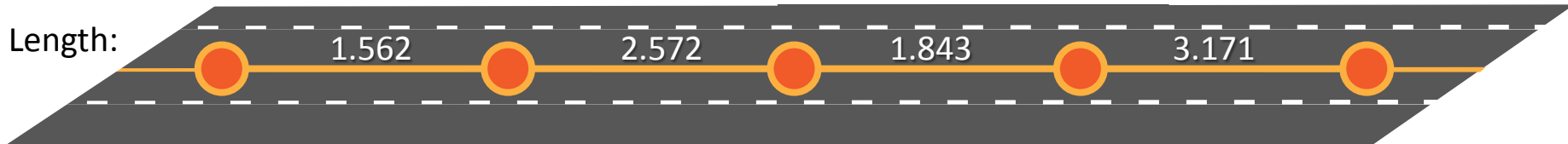
$\textit{maxTTTR}_i$  = the maximum TTTR of all five time periods for segment  $i$  (nearest hundredth)

$SL_i$  = length of segment  $i$

$T$  = total number of Interstate segments



# Freight Reliability Measure: Example



TTTR	1.50	2.10	1.45	1.56
	1.38	1.83	1.71	2.30
	1.70	1.79	1.62	2.12
	1.30	1.42	1.22	1.82
	1.21	1.03	1.01	1.27

$$\begin{aligned}
 \text{TTTR} &= \frac{(1.70 \times 1.562) + (2.10 \times 2.572) + (1.71 \times 1.843) + (2.30 \times 3.171)}{(1.562 + 2.572 + 1.843 + 3.171)} \\
 &= \frac{2.655 + 5.401 + 3.152 + 7.293}{9.148} \\
 &= 2.022
 \end{aligned}$$

# Subpart G Measures

- **PHED Measure:** Annual Hours of Peak Hour Excessive Delay (PHED) Per Capita
- **Non-SOV Travel Measure:** Percent of Non-Single Occupancy Vehicle (SOV) Travel



# § 490.703 Applicability: PHED and Non-SOV Travel Measures

- Areas with the following criteria:

## ***Area Characteristics***

- Designated urbanized area,
- Contains NHS mileage, **AND**
- Population over 200,000\*



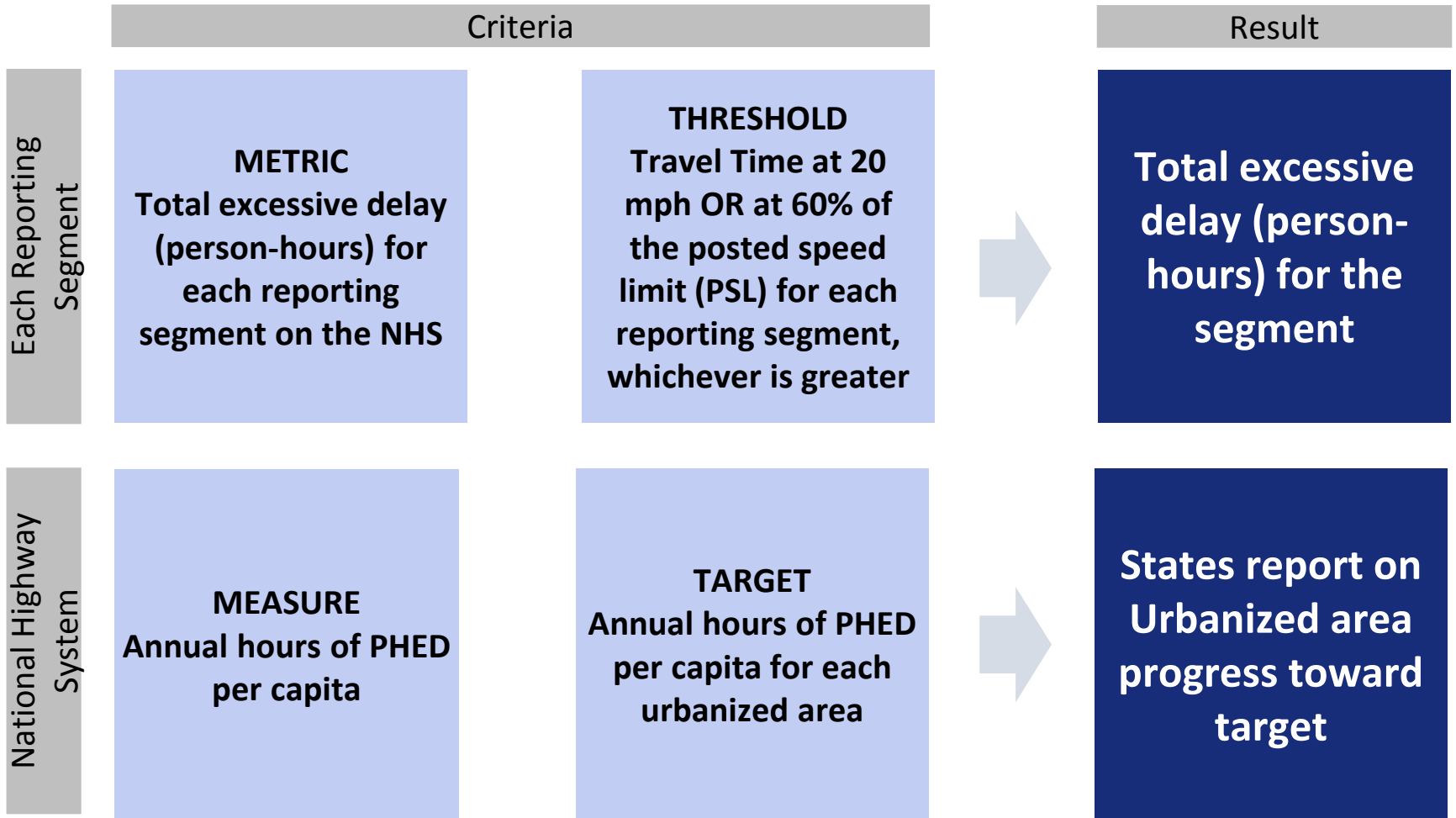
## ***Nonattainment or Maintenance Area***

- ozone (O<sub>3</sub>),
- carbon monoxide (CO), **OR**
- particulate matter (PM<sub>10</sub> or PM<sub>2.5</sub>)

- **All MPOs and State DOTs** that have NHS mileage that overlaps with an applicable urbanized area must coordinate on a **single, unified target** and report on the measures

\* *For the first performance period only, applies to urbanized areas with populations over 1 million*

# § 490.707 Peak Hour Excessive Delay (PHED) Measure



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## ***PHED Required Data***

- Travel time segment length
- Epoch (time interval, i.e., 15-minute units)
- Travel time: all vehicles
- Posted speed limit
- Urbanized area designation



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## ***PHED Required Data***

- 15-minute volume for each segment and epoch (peak hours only)
- Percent of total traffic for: (1) cars, (2) buses, and (3) trucks on the segment
- Average vehicle occupancy for (1) cars, (2) buses, and (3) trucks on the segment (agency or FHWA supplied)
- Urbanized area population



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## ***Urbanized Areas: Boundaries & Population***

- Boundaries may be attained from the U.S. Census Bureau:
  - [https://www.census.gov/geo/maps-data/data/cbf/cbf\\_ua.html](https://www.census.gov/geo/maps-data/data/cbf/cbf_ua.html)
- FHWA-approved urbanized area boundaries submitted to HPMS by a state DOT may also be used
- Urbanized area population, for use in measure calculation, is provided via the 5-year estimates from the American Community Survey (Census)



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## *Definition of Excessive Delay*

- The extra amount of time spent in congested conditions defined by speed thresholds that are lower than a normal delay threshold
- For the purposes of this rule, the speed threshold is 20 miles per hour (mph) or 60% of the posted speed limit, whichever is greater



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## ***Definition of Peak Periods***

- Calculations only need to be done for the following hours for ***weekdays*** (total 8 hours per day)
  - Morning Peak Hours are 6:00 a.m. – 10 a.m.
  - Afternoon Peak Hours are either (agency choice):
    - 3:00 p.m. – 7:00 p.m. or
    - 4:00 p.m. – 8:00 p.m.



# Overview: PHED Metric: Example

0.500 Mile Reporting Segment



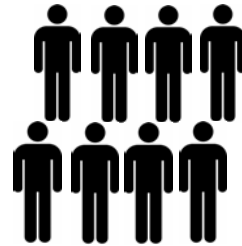
Average of 105 seconds for a 15-min. segment per vehicle



Excessive Delay Threshold: 90 seconds



$105 - 90 =$   
**15 seconds**

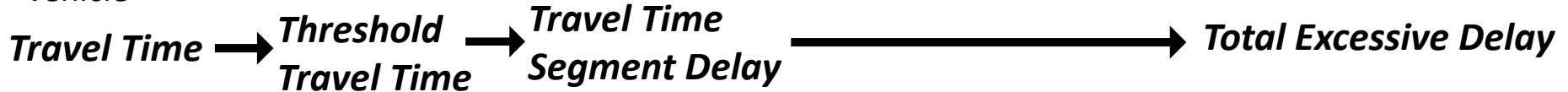


500,000 people traveling during peak hours



For all peak periods in a full calendar year

**= 863.025 person-hours**





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## ***(PHED) Metric Calculation***

$$1. \text{EDTTT}_s = \left( \frac{SL_s}{\text{Threshold Speed}_s} \right) \times 3,600$$

$\text{EDTTT}_s$  = Excessive Delay Threshold Travel Time  
= travel time on the segment above which  
delay would be incurred

$SL_s$  = length of the segment

$\text{Threshold Speed}_s$  is the larger of:

- 20 mph, or
- Posted Speed Limit x 0.6



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## ***PHED Metric Calculation***

**2.**  $RSD_{s,b} = Travel\ Time_{s,b} - EDTTT_s$

$RSD_{s,b}$  = travel time segment delay for  
segment  $s$  and 15-minute bin  $b$

$Travel\ Time_{s,b}$  = travel time of all vehicles on  
segment  $s$  and 15-minute bin  $b$



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## ***PHED Metric Calculation***

$$3. \text{ ExcessiveDelay}_{s,b} = \begin{cases} \frac{RSD_{s,b}}{3,600} & \text{when } RSD_{s,b} \geq 0 \\ \text{or} \\ 0 & \text{when } RSD_b < 0 \end{cases}$$

*Excessive Delay* is in hours (nearest hundredth)



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## PHED Metric Calculation

### 4. Total Excessive Delays<sub>s</sub>

$$\begin{aligned} &= AVO \\ &\times \sum_{d=1}^{TD} \sum_{h=1}^{TH} \sum_{b=1}^{TB} \left( ED_{s,b,h,d} \right. \\ &\times \left. \frac{\text{hourly volume}}{4} \text{ } s, h, d \right) \end{aligned}$$

*Total Excessive delay<sub>s</sub>* = person-hours of delay (nearest hundredth) for the entire year for segment *s*



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## ***PHED Metric Calculation (continued)***

$$\begin{aligned}AVO &= \text{Average Vehicle Occupancy} \\ &= (P_c \times AVO_c) + (P_b \times AVO_b) \\ &\quad + (P_t \times AVO_t)\end{aligned}$$

$P_c$  = percent of cars in the traffic stream

$P_b$  = percent of buses in the traffic stream

$P_t$  = percent of trucks in the traffic stream

$AVO_c$  = average vehicle occupancy for cars

$AVO_b$  = average vehicle occupancy for buses

$AVO_t$  = average vehicle occupancy for trucks



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## ***PHED Metric Calculation (continued)***

$s$  = reporting segment

$d$  = a day of the reporting year

$TD$  = total number of days in a year

$h$  = hour of the day (pre-defined peak hours only)

$TH$  = total number of hour intervals in day  $d$

$b$  = 15-minute bin for hour  $h$



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## ***PHED Metric Calculation (continued)***

$TB$  = total number of 15-minute bins with travel times present in peak hour  $h$

*Excessive Delay* $_{s,b,h,d}$  = excessive travel time (hundredths of an hour) for segment  $s$ , bin  $b$ , peak hour  $h$ , and day  $d$



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## ***PHED Measure Calculation***

$$\begin{aligned} & \textit{Annual Hours of PHED per capita} \\ &= \frac{\sum_{s=1}^T \textit{Total Excessive Delays}_s}{\textit{Total Population}} \end{aligned}$$

*Total Population* = the total population in the urbanized area from the most recent annual population published by the U.S. Census





# PHED METRIC Calculation: Example

Date	Start Time	Speed Threshold	Segment Length	Travel Time	15-Min Volume
3/15/2013	7:00	36	0.52	45	1,220
3/15/2013	7:15	36	0.52	51	1,220
3/15/2013	7:30	36	0.52	63	1,220

**For 7:30:**  $EDTTT = \left( \frac{0.52}{36} \right) \times 3,600$   
 $= 52 \text{ sec}$

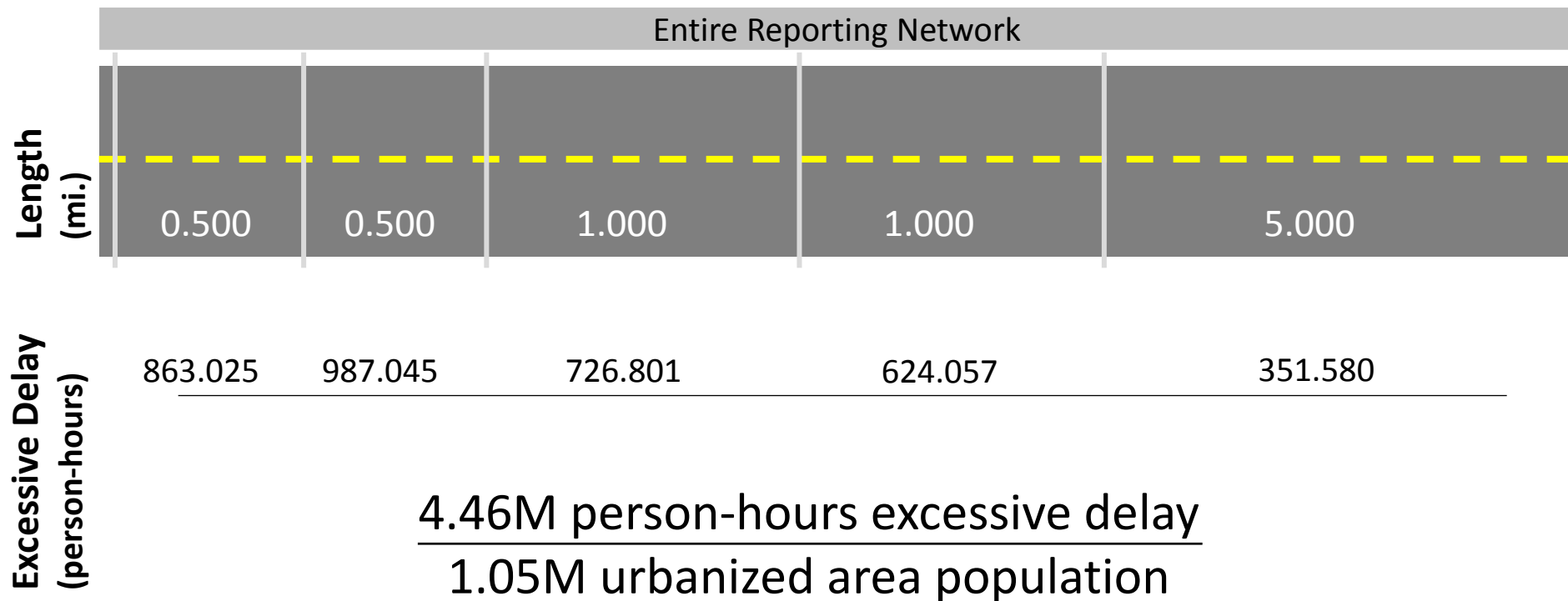
$RSD = 63 - 52$   
 $= 9 \text{ sec}$

Excessive Delay  $= \frac{9}{3,600}$   
 $= 0.003 \text{ hrs}$

Total Excessive Delay  $= 0.003 \times 1,220 \times 1.1 \text{ AVO}$   
 $= 3.66 \text{ vehicle-hrs}$   
 $\quad \times 1.1 \text{ AVO}$   
 $= 4.03 \text{ person-hours}$



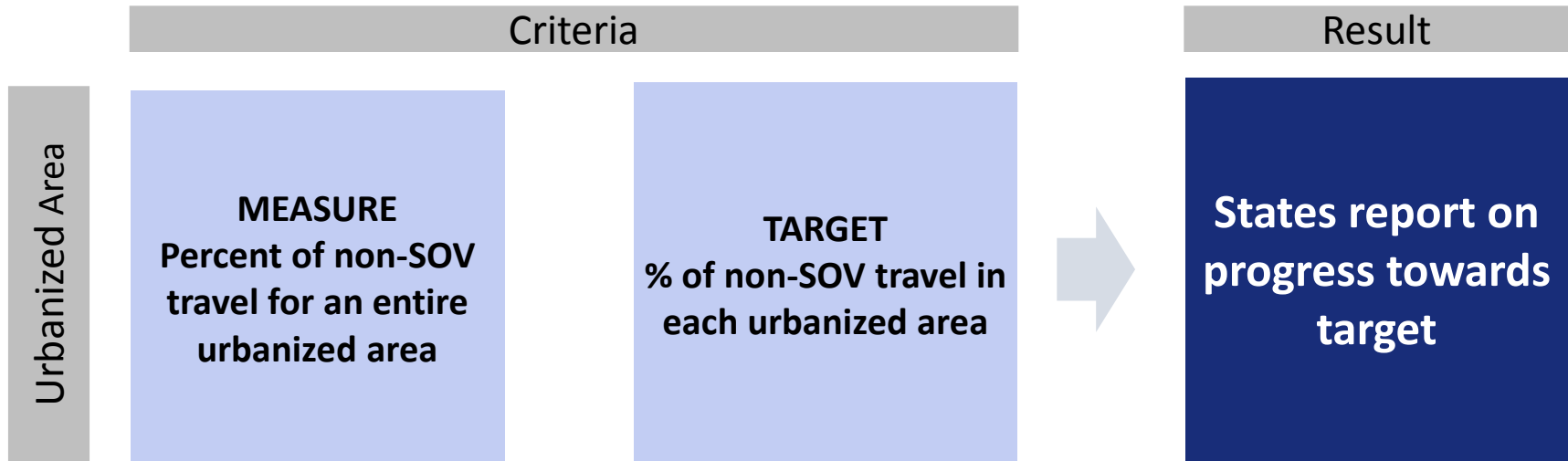
# PHED MEASURE Calculation: Example



Measure: Peak hour excessive delay per capita



# § 490.707 Non-SOV Travel Measure



## ***§ 490.709 Data Requirements for Non-SOV Travel Measure***

- Based on person travel
- Requires estimates of the number of people traveling by single occupancy and non-single occupancy vehicles
- Computed to 0.1%
- Can be developed from one of three data sources and methods
  - A. American Community Survey (ACS)
  - B. Local travel survey
  - C. System use measurement



# ***§ 490.709 Data Requirements for Non-SOV Travel Measure***

<b>Option</b>	<b>Relevant Data</b>	<b>Source</b>
<b>Method A</b>	<ul style="list-style-type: none"> <li>• <b>5-Year Estimate for “Commuting to Work” totaled by mode, as of August 15 the year Performance Report is due</b></li> </ul>	<ul style="list-style-type: none"> <li>• American Community Survey (Table DP03)</li> </ul>
<b>Method B</b>	<ul style="list-style-type: none"> <li>• <b>Travel mode choices gathered within 2 years of the start of Performance Period</b></li> </ul>	<ul style="list-style-type: none"> <li>• Local Survey</li> </ul>
<b>Method C</b>	<ul style="list-style-type: none"> <li>• <b>Sample or continuous count of travelers using different modes</b></li> </ul>	<ul style="list-style-type: none"> <li>• Modal Counts</li> </ul>

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## ***§ 490.713 Non-SOV Travel Measure***

Based on one of three methods

- A. 100% - SOV% travel
- B. Results of local survey
- C. 
$$\frac{\text{Annual volume of non-SOV}}{\text{Total annual volume}}$$

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## ***Method A: American Community Survey (Default)***

- Use “5 Year Estimate” DP03 Table
  - “Commuting to Work” section
  - “Estimate” column

$$\% \text{ nonSOV Travel} = 100\% - \% \text{ SOV Travel}$$

- Based on work trips only
- Assumes all other modes, including telecommuting, are part of non-SOV travel

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## ***Method B: Local Travel Survey***

- % non-SOV travel is that travel that is not occurring by driving alone in a motorized vehicle, including telecommuting
- May be for work trips or all trips
- Needs to have been conducted as recently as 2 years prior to the reporting period





## ***Method C: System Use Measurement***

- Based on counts of travelers
- Sample or continuous methods can be used

*% nonSOV travel*

$$= 100 \times \left( \frac{Volume_{nonSOV}}{Volume_{nonSOV} + Volume_{SOV}} \right)$$

$Volume_{SOV}$  = annual person volume of travelers making trips by driving alone

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## ***Example: Method A (ACS Data)***

$$\begin{aligned}\% \text{SOV Travel} &= \frac{\text{Workers who drove alone}}{\text{Total workers}} \\ &= \frac{1,346,658}{1,602,992} \\ &= 84.0\%\end{aligned}$$

$$\begin{aligned}\% \text{NonSOV Travel} &= 100\% - 84.0\% \\ &= 16.0\%\end{aligned}$$