



Travel Time-Based Performance Measures

Learning Outcomes

- Define travel time and travel time reliability
- Discuss the importance of travel time and travel time reliability
- List performance measures related to travel time
- Define the terms Cumulative Distribution Function and Probability Density Function and explain their use in measuring performance
- Explain the use of the Travel Time Index and the Planning Time Index in measuring performance
- Calculate performance measures from raw data
- Discuss how decision makers use performance measures

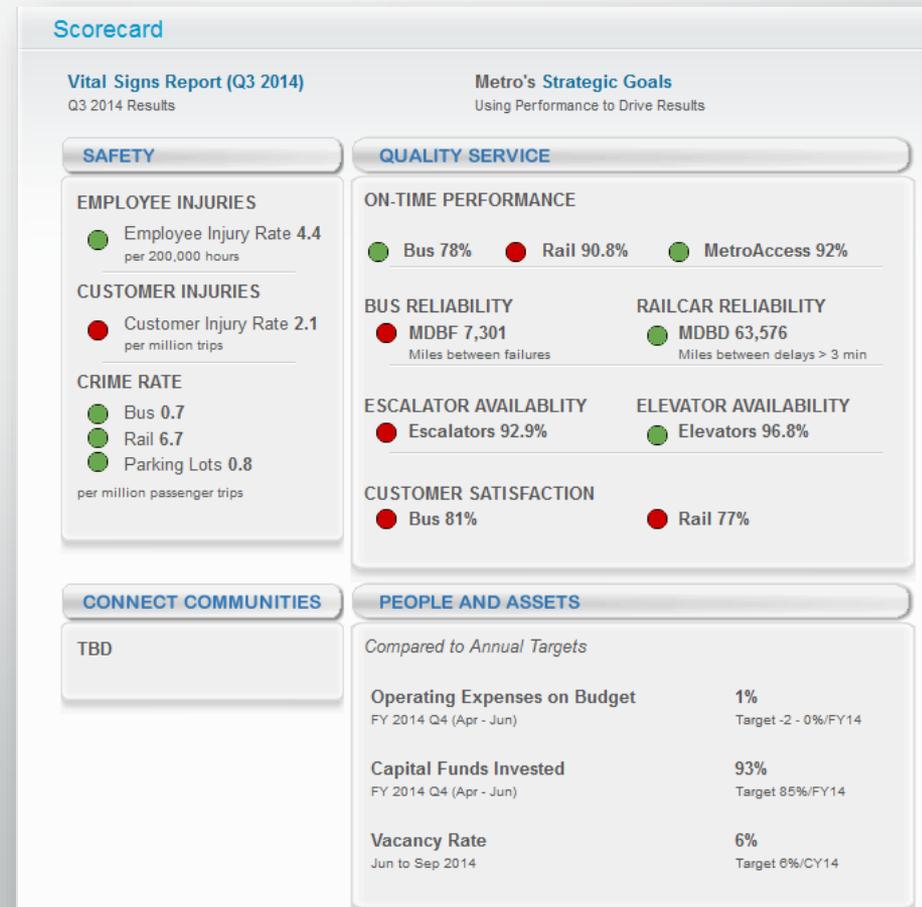
Performance Measures

- Defined as statistically based evidence used to track the progress towards preset objects
- Used in a variety of disciplines (health, business, etc.)
- **Name some non-transportation performance measures**
- In transportation, performance monitoring using performance measures has become essential under the Moving Ahead for Progress in the 21st Century Act (MAP-21)

Transportation Performance Measures

- Every aspect of transportation engineering has a set of performance measures to keep track of how well facilities operate.

WMATA.com (12/16/2014)



Transportation Performance Measures

Maryland's 2014 Annual Attainment Report of Transportation System Performance

SHA & MDTA: Percent of Roadway Miles with Acceptable Ride Quality*

The traveling public has identified acceptable ride quality (i.e., the smoothness or roughness of the pavement) as a priority. Ride quality facilitates mobility, efficiency and safe movement of people and goods within Maryland.



* Ride quality is represented by the International Roughness Index (IRI). The SHA inventory of mainline directional miles, which is a component of this measure, now include routes of less than one mile in length so that the SHA network is more accurately and completely represented.

**2013 data is preliminary and subject to change.

What is Travel Time and Travel Time Reliability?

- Travel time (how long it takes to get from A to B) is a measure of the impact of recurrent (repeatable) congestion
- Travel time reliability (how the time it take to A to B can vary) is a measure of the impact of non-recurrent (non-repeating) congestion
- Recurrent congestion is caused by commuter traffic, shopping traffic, etc.
- Non-recurrent congestion is caused by unanticipated events such as crashes, special events, weather and construction

Why are Travel Time and Travel Time Reliability Important?

- Travel time and travel time reliability are transportation system measures of mobility
- These two measures are extremely important to travelers and shippers
- Transportation costs are influenced by the values of travel time and travel time reliability
- They are among the most significant transportation performance measures
- They are usually based on travel time percentiles which often follow statistical distributions

Performance Measures Based on Travel Time

- Copious amounts of travel time data made available through third-party vendors have allowed DOTs to utilize travel time/speed for their performance measures
- These performance measures quantify travel time and travel time reliability in a way that the performance of facilities with different lengths and or capacity can be compared using the same metric

Terminology – Statistics

- Probability Density Function (PDF) – describes the likelihood that a variable will assume a (range of) given value(s).
- Cumulative Distribution function (CDF) – the probability that a variable with a given distribution will assume a value less than or equal to a given value.

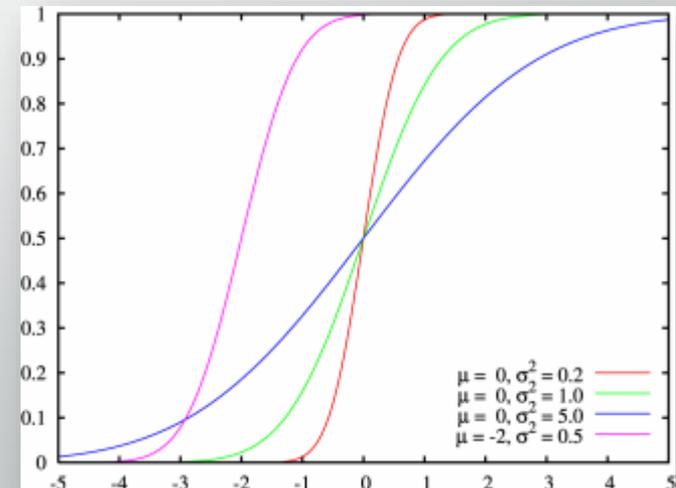
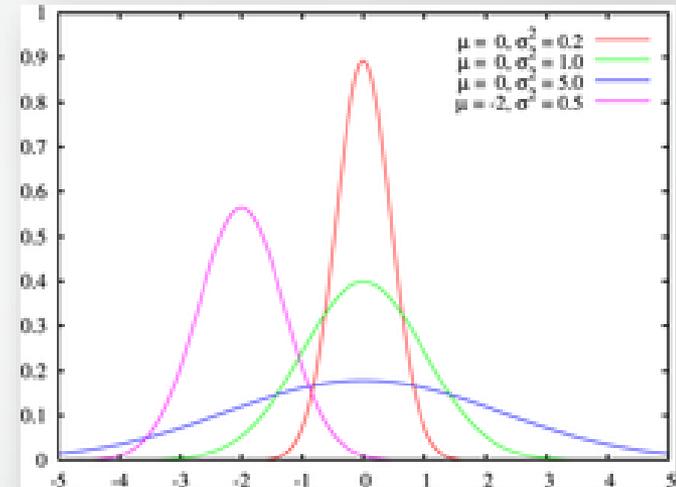
PDF CDF Examples

Probability Density Function (PDF):

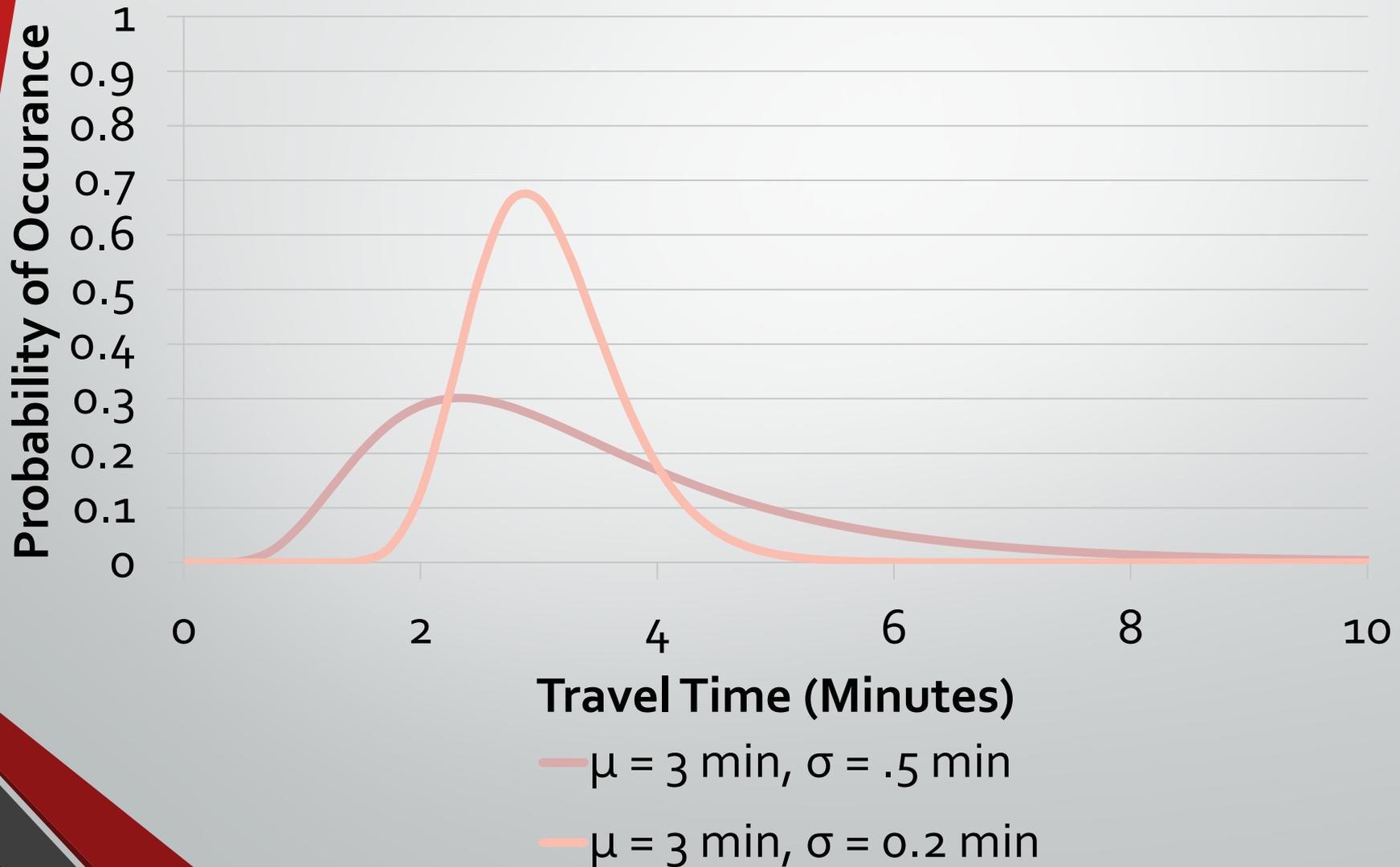
Plots of several hypothetical normal distributions with various means (μ) and variance (σ^2). For transportation applications, horizontal axis could represent various travel times while vertical axis could represent the probability of their occurrence.

Cumulative Distribution Function (CDF):

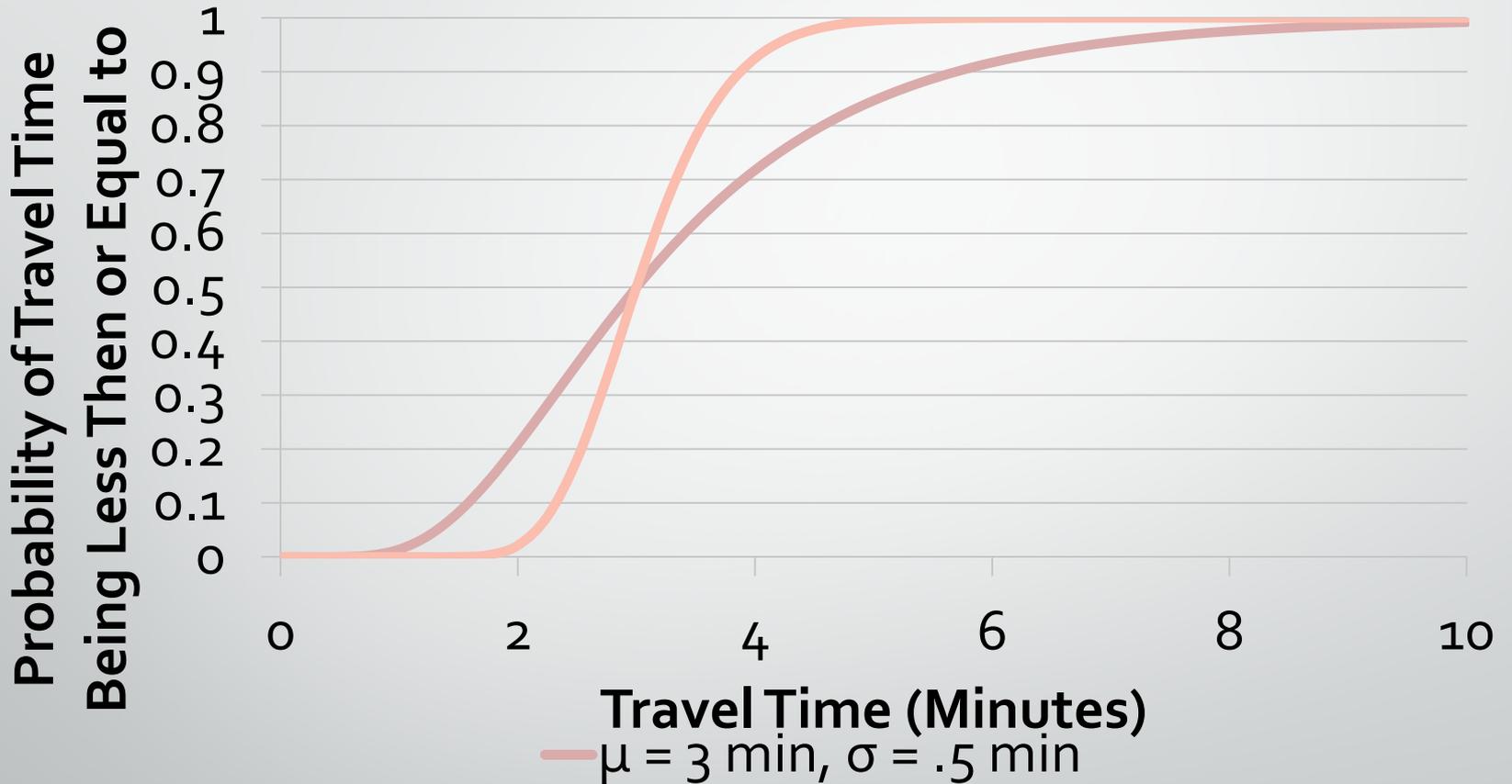
The CDF is a plot of the same data as the PDF. Curves with the same colors represent the corresponding PDF plot. These curves indicate the probability that the travel time will be less than or equal to the value on the X axis.



The Probability Density Function

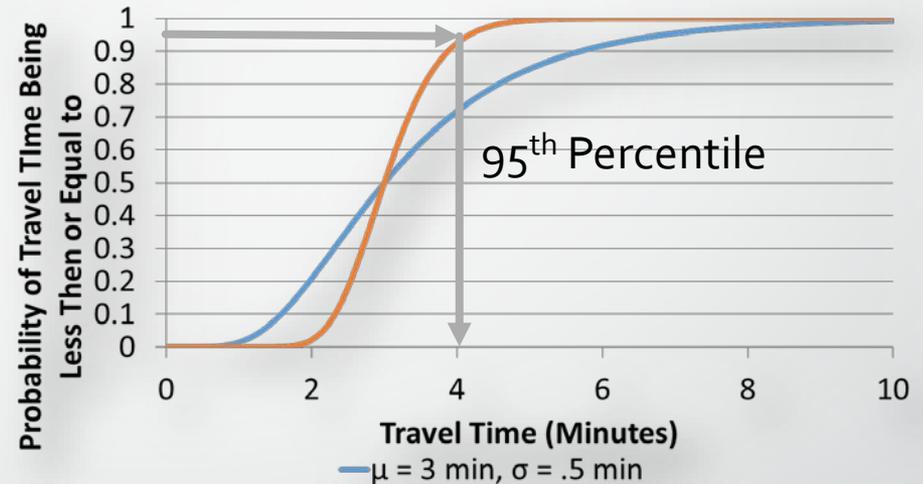


Cumulative Distribution Function



Using Values from CDFs for Performance Measures

- Percentiles from the CDF along with free flow travel time are used to calculate several different type of performance measures



- DOTs either create their own or use commonly adopted performance measures, which ever meet their needs
- See the next few slides for the performance measures many jurisdictions use

Travel Time (Index)

- Travel time by itself cannot quantify recurrent congestion since it is dependent on a facility's length
- The Travel Time Index (TTI) is often used instead

- TTI represents the order of magnitude the free flow travel time increases during the time period the travel times were collected (usually rush hour)

TTI Questions

- The less a roadway's TTI is, the _____ the road suffers from recurrent congestion
- If the free flow travel time on your commute to work is 15 minutes and the rush hour TTI is 1.33, how long does it take you on average to get to work during rush hour?

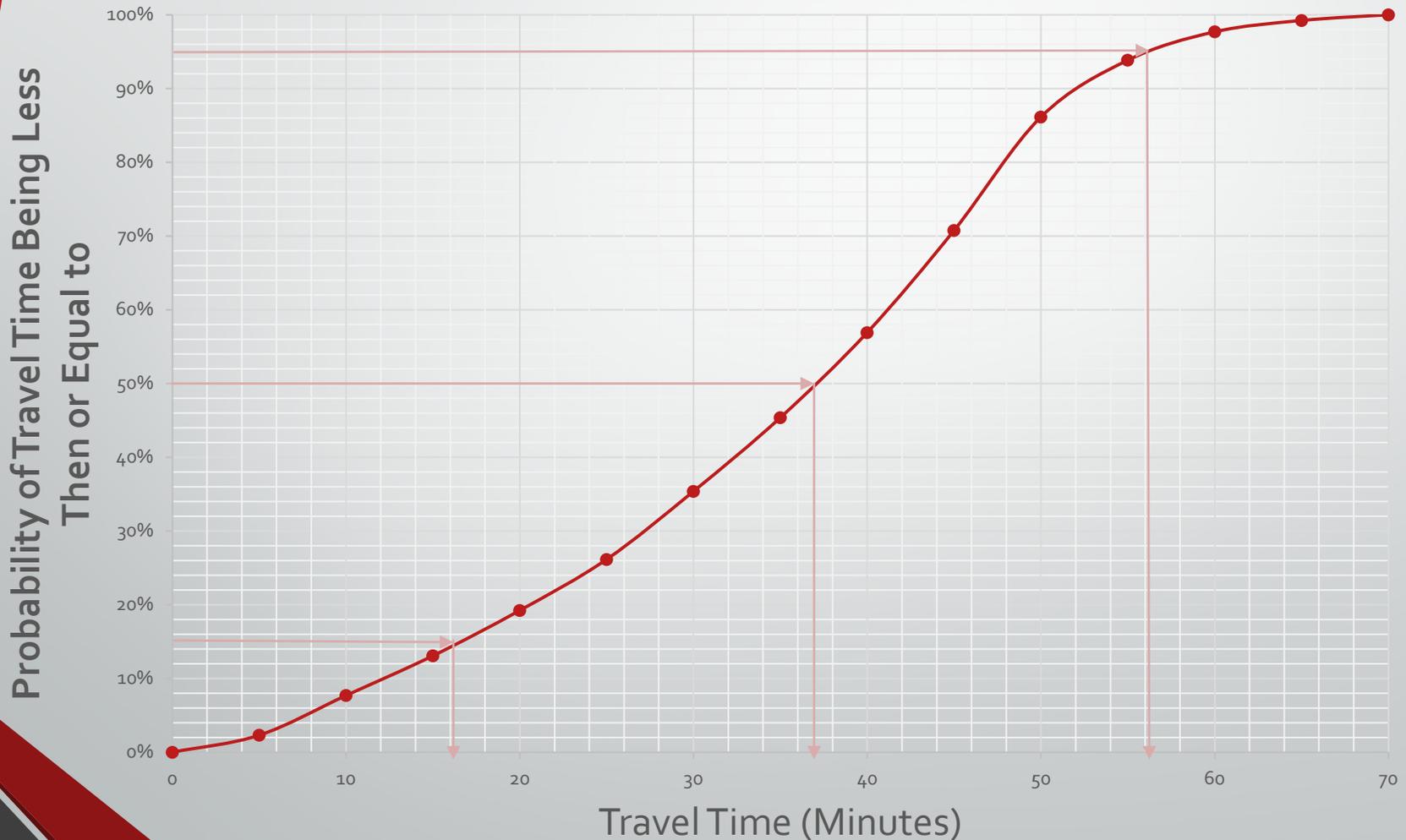
Planning Time Index

- Planning Time Index (PTI) is a travel time reliability performance measure
- PTI is a multiplier that can be applied to the free flow travel time to get the travel time needed to be on time 95% of the time
- PTI compares how bad roads' worst travel times are and how much roads suffer from non-recurrent congestion

PTI Questions

- The greater a roadway's PTI is, the _____ reliable a roadway is
- Can a roadway have a relatively high PTI and low TTI?

Calculate the PTI and TTI* if the free flow travel time is the 15th percentile



* Use 50th percentile travel time for calculating TTI

Where does data come from?

- Travel time data can come from a variety of sources from devices along roadways to cell phone/ GPS data collected by third party vendors (vehicle probe data)
- The I-95 Corridor Coalition allows states to purchase third party travel time with a set a tools used to use the travel time data
- This initiative is called the Vehicle Probe Project

Calculating PM from Raw Data

- This data come from the I-95 Corridor's Vehicle Probe Project Suite Massive Raw Data Downloader
- Data comes in tables
- TMC_Code identifies a certain stretch of road
- Measurement-tstamp refers to when the speed reading was taken
- Speed is the speed of traffic at the time stamp on the stretch of road (MPH)
- Average_speed is the average speed of the stretch of road during that time period throughout the year (MPH)

tmc_code	measurement_ts	speed	average_s	reference	travel_time	confidence	cvalue	
110P04461	1/1/2013 7:00	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:01	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:02	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:03	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:04	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:05	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:06	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:07	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:08	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:09	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:10	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:11	56	57	57	0.31	20	0	
110P04461	1/1/2013 7:12	56	57	57	0.31	20	0	

- Reference_speed is the free flow speed the stretch of roadway (MPH)
- Travel_time is the travel time derived from the speed reading (minutes)
- Confidence_score and cvalue refer to the accuracy of the speed data.

1. Download Data

1. Roads

Road Region List of TMC codes Saved TMC Set

Enter your TMC codes as a comma-separated list (e.g. 110+04645,110P04645,110+04646). Auto refresh map

103+04133

Your selected roads

1 tmc

2. Date Range

01/01/2013 - 12/31/2013

3. Days of week

Sun Mon Tue Wed Thu Fri Sat

4. Time of day

07:00 AM -to- 09:00 AM

04:00 PM -to- 06:00 PM

5. Fields

Speed Historic average speed Reference speed

Travel time Confidence score C-Value

6. Averaging

Don't average 5 minutes 10 minutes

15 minutes 30 minutes 1 hour

7. Description

What geography?

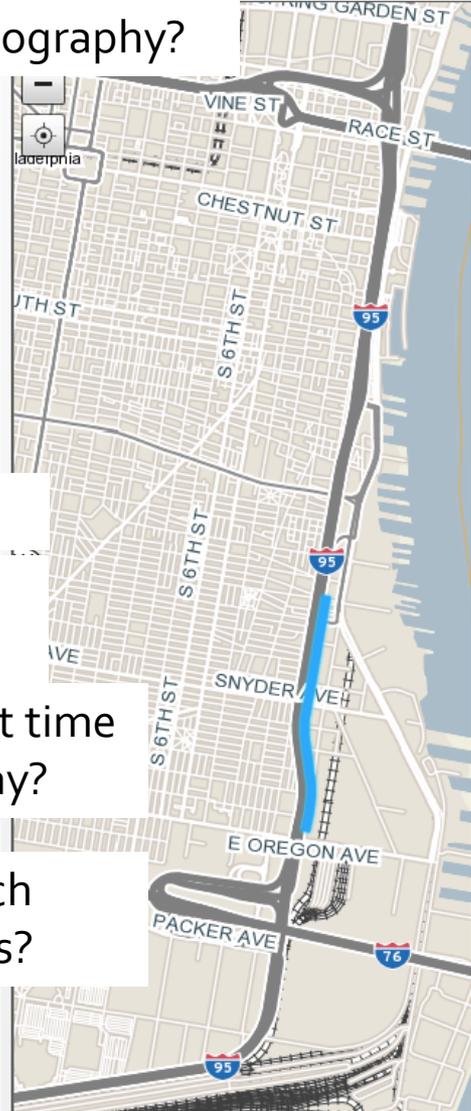
What date range?

What days of the week?

What time of day?

Which fields?

What granularity?



3. Calculate Percentiles

- Use Excel's PERCENTILE.EXC command which calculates percentiles based on a selected array
 - Don't forget to use '\$' when referring to the array
- If you had travel time data for a given period of time, how could you calculate performance measures?

The screenshot shows an Excel spreadsheet with the following data:

	I	J	K	L	M	N
1						
2		Percentile	Speed			
3		0.05	58			
4		0.1	59			
5		0.15	60			
6		0.2	61			
7		0.25	62			
8		0.3	63			
9		0.35	63			
10		0.4	63			
11		0.45	63			
12		0.5	64			
13		0.55	64			
14		0.6	64			
15		0.65	64			
16		0.7	65			
17		0.75	66			
18		0.8	66			
19		0.85	67			
20		0.9	67			
21		0.95	68			

The formula bar shows: `=PERCENTILE.EXC(C2:C37361,J3)`

Callout box: `(Speed/Travel Time Array, Percentile)`

Calculate Performance Measures

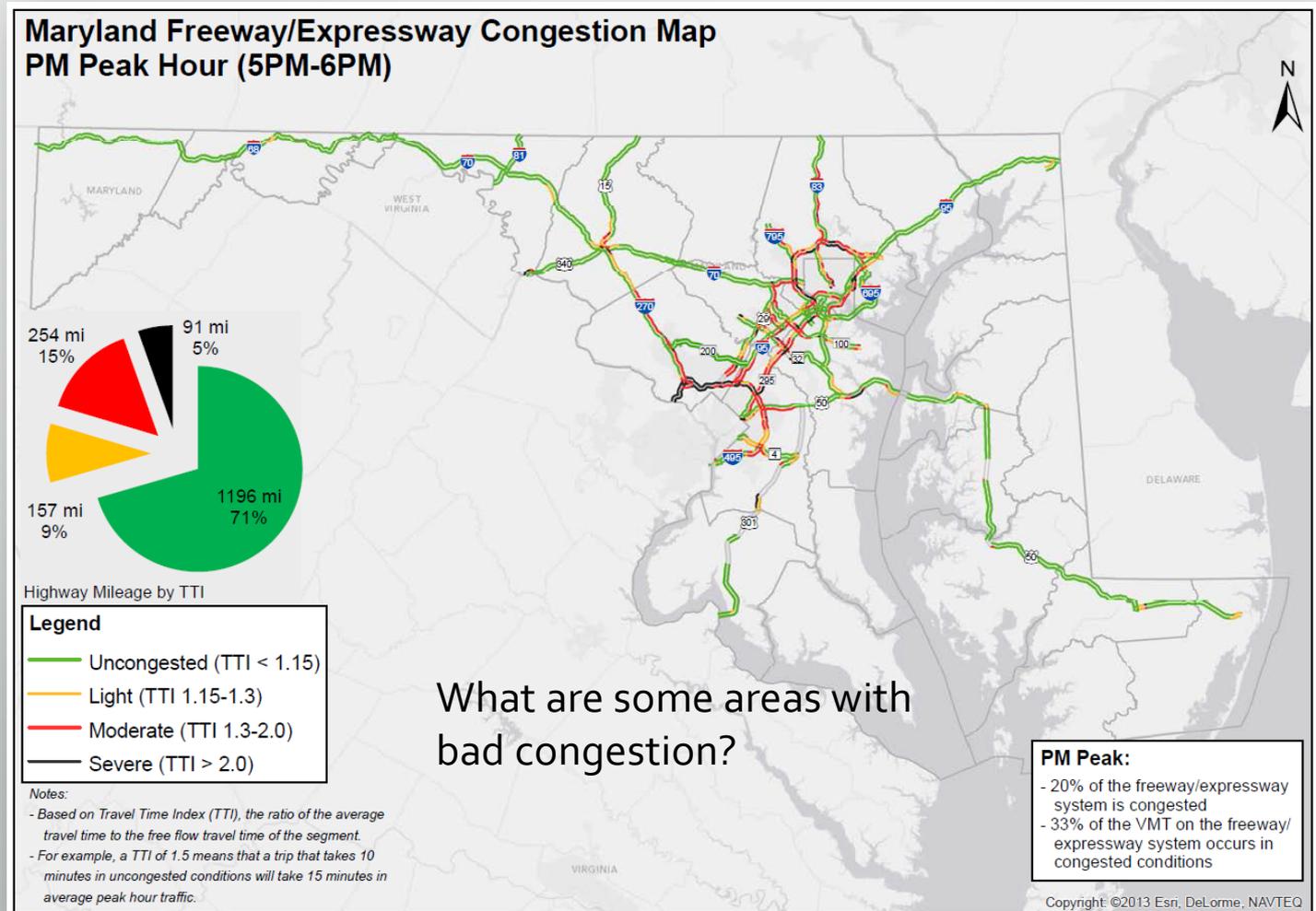
- To calculate percentile-based performance measures simply plug in the percentiles calculated into the performance measure equation
- Free-flow travel time can be given or assumed (85th percentile, reference speed, speed limit, etc.)
- What would the TTI be? (X & Y)

	J	K	L	M	N
1					
2	Percentile	Speed			
3	0.05	58			
4	0.1	59			
5	0.15	60			
6	0.2	61		TTI	=X/Y
7	0.25	61			
8	0.3	62			
9	0.35	62			
10	0.4	62			
11	0.45	62			
12	0.5	63			
13	0.55	63			
14	0.6	63			
15	0.65	63			
16	0.7	64			
17	0.75	64			
18	0.8	64			
19	0.85	65			
20	0.9	66			
21	0.95	67			
22	Free flow	65			

Using Performance Measures

- If performance measures are available for a whole roadway network, it gives decisions makers information of which parts of the transportation network are operating well and which need investment to improve operations
- If a particular stretch of roadway is monitored before and after an improvement, the resulting performance measures can show if the improvement was justified

Performance Measure Application Example (General Awareness)



Source: 2013 Maryland Mobility Report

Performance Measure Application Example (Investment Prioritization)

- Rankings of the worst segments in an area help decision makers focus on key areas
- Engineering judgment, politics, and policy also play a role

B. Top 30 Unreliable Segments

The Planning Time Index (PTI) is a measure of the variability in travel time a motorist should plan for taking into account potential impacts due to such elements as weather. The PTI was calculated for the AM peak hour (7-8 AM) and the PM peak hour (5-6 PM) for expressways/freeways based on INRIX data limits which define multiple sections between interchanges. The top 30 most unreliable roadway segments for the AM and PM peak hour are listed in the following tables.

TOP 30 UNRELIABLE SEGMENTS AM PEAK 2012

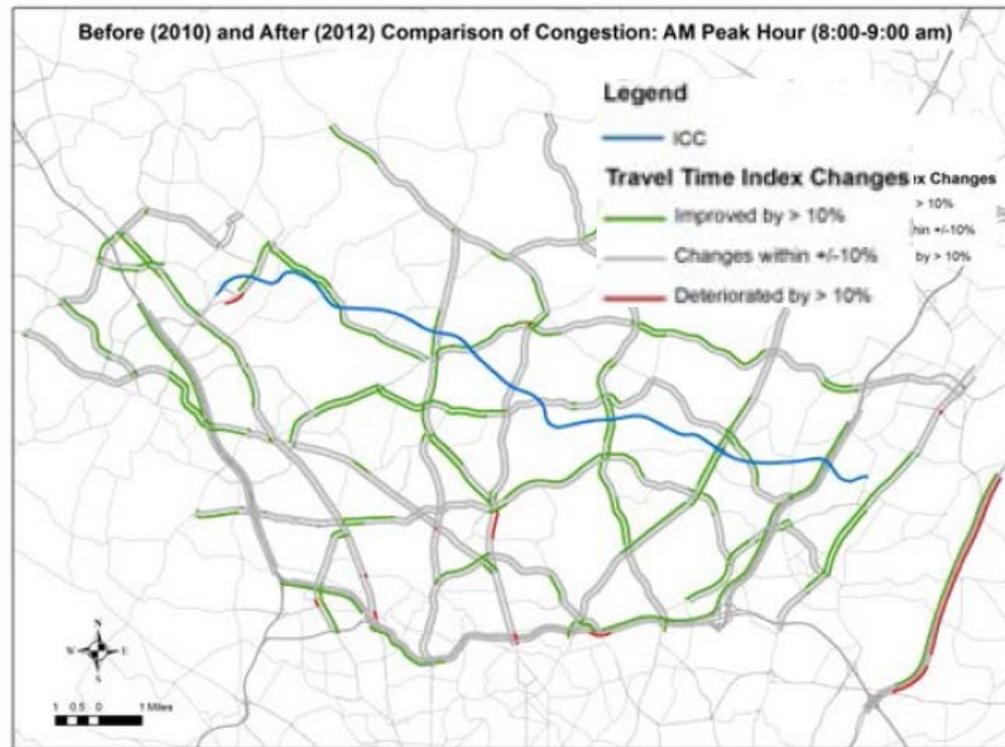
2012 Rank	Road	Location	Direction	2012 PTI	2011 Rank	Rank Change
1	I-495	I-95 to Montgomery CO/L	Outer Loop	6.30	1	0
2	I-495	@ MD 650**	Outer Loop	6.00	4	-2
3	I-495	Prince Georges CO/L to MD 650	Outer Loop	6.00	2	+1
4	I-495	MD 650 to MD 193**	Outer Loop	5.25	9	-5
5	I-695	MD 147 to MD 41	Outer Loop	5.17	8	-3

Source: 2013 Maryland Mobility Report

Performance Measure Application Example (Investment Justification)

2013 *Maryland* State Highway Mobility Report

CHANGE IN CONGESTION LEVELS IN THE MD 200 REGION BETWEEN 2010 (BEFORE) AND 2012 (AFTER)



Source: 2013 Maryland Mobility Report