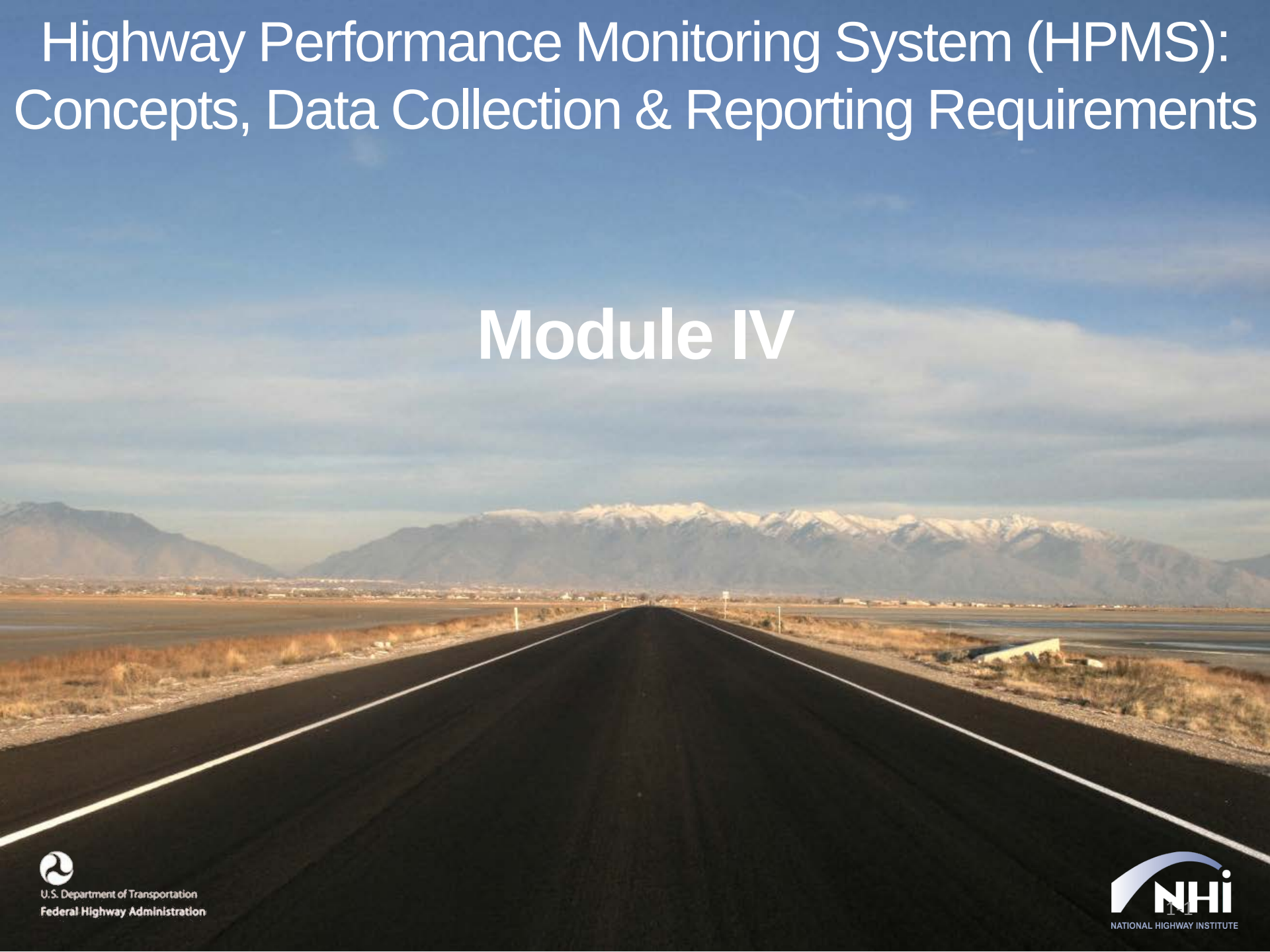
# Highway Performance Monitoring System (HPMS): Concepts, Data Collection & Reporting Requirements



## Module IV

U.S. Department of Transportation
Federal Highway Administration

NHI
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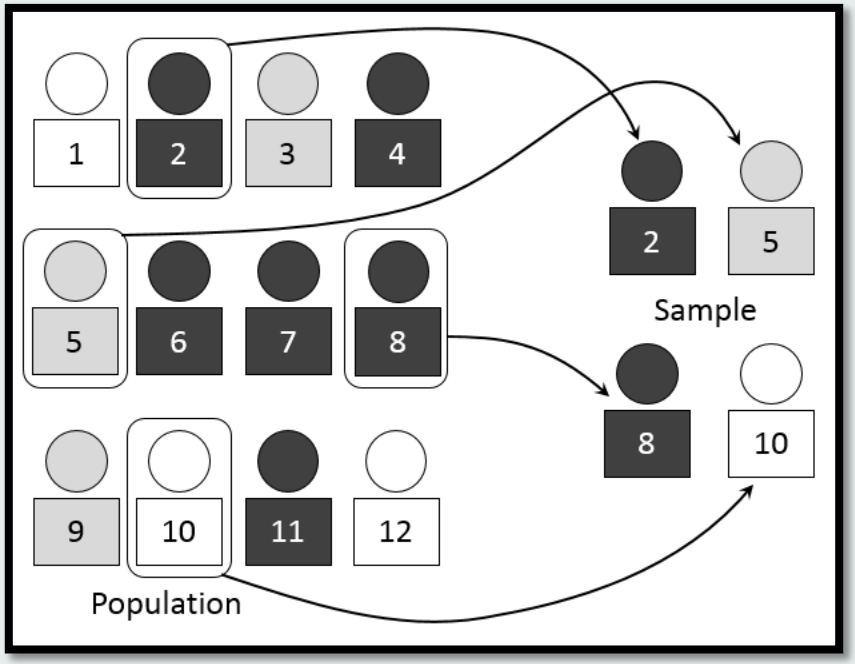
# Sampling

Lesson 1:  Sampling Framework

Lesson 2:  AADT Volume Groups, Precision Levels, and Sample Size Estimation Procedure

# Lesson One

## Sampling Framework




Source: http://www.netquest.com/blog/wp-content/uploads/2015/03/Simple_random_sampling.png

# Lesson 1 Introduction

- Sample data is used to describe detailed roadway characteristics:
  - Performance
  - Condition
  - Use
- Sample sections - statistically derived subset of the Full Extent road network (i.e., the Federal-aid System)
- Sample data are expanded to represent an entire road network

# Use of Sample Data (Example)

## Lane Width

Lane width affects capacity and safety. Narrow lanes have a lower capacity and can affect the frequency of crashes. As with roadway alignment, lane width is more crucial on functional classifications with higher travel volumes.

Currently, higher functional systems such as the Interstate System are expected to have 12-foot lanes. As shown in *Exhibit 3-5*, approximately 99.0 percent of rural Interstate System miles and 98.6 percent of urban Interstate System miles had minimum 12-foot lane widths in 2008.

**Exhibit 3-5** Lane Width by Functional Class, 2008

| | ≥ 12 foot | 11 foot | 10 foot | 9 foot | < 9 foot |
|---|---|---|---|---|---|
| Rural | | | | | |
| Interstate | 99.0% | 1.0% | 0.0% | 0.0% | 0.0% |
| Other Principal Arterial | 90.6% | 7.3% | 1.4% | 0.4% | 0.2% |
| Minor Arterial | 72.3% | 18.3% | 8.5% | 0.8% | 0.2% |
| Major Collector | 40.5% | 25.0% | 26.3% | 6.0% | 2.1% |
| Urban | | | | | |
| Interstate | 98.6% | 1.0% | 0.1% | 0.1% | 0.2% |
| Other Freeway and Expressway | 94.8% | 3.9% | 0.4% | 0.1% | 0.8% |
| Other Principal Arterial | 79.9% | 13.0% | 5.5% | 0.5% | 1.0% |
| Minor Arterial | 64.1% | 19.2% | 13.6% | 1.7% | 1.5% |
| Collector | 49.8% | 19.3% | 22.9% | 5.7% | 2.4% |

Note: The most recent lane width data available through HPMS is for 2008; due to changes in the HPMS data structure, more recent data cannot yet be extracted.
Source: Highway Performance Monitoring System as of December 2009.

In 2008, approximately 49.8 percent of urban collectors have lane widths of 12 feet or greater, but approximately 19.3 percent have 11-foot lanes and 22.9 percent have 10-foot lanes; the remaining 8.1 percent have lane widths of 9 feet or less. Among rural major collectors, 40.5 percent have lane widths of 12 feet or greater, but approximately 25.0 percent have 11-foot lanes and 26.3 percent have 10-foot lanes. Roughly 8.1 percent of rural major collector mileage has lane widths of 9 feet or less.

Source: FHWA Conditions and Performance Report, 2013

# Terminology

- ***Universe*:** “a population from which a sample is taken”

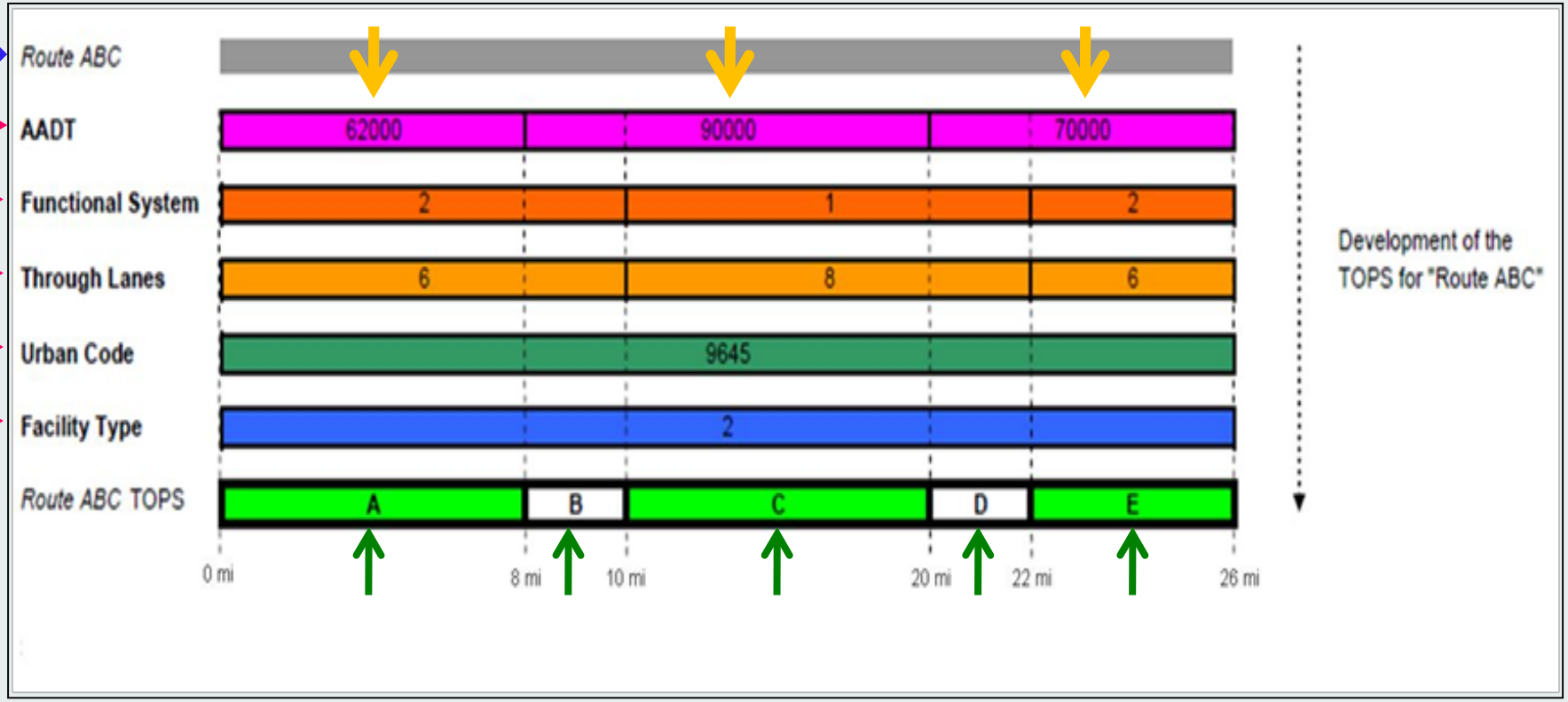
- ***Sampling Units*:** “elements within a population that can be counted or surveyed”

- ***Sampling Frame*:** “a list of all eligible sampling units in a universe”

# HPMS Context

- ***Universe*:** Full Extent of the Federal-aid System
- ***Sampling Units*:** HPMS sample sections
- ***Sampling Frame*:** Table of Potential Samples (TOPS)

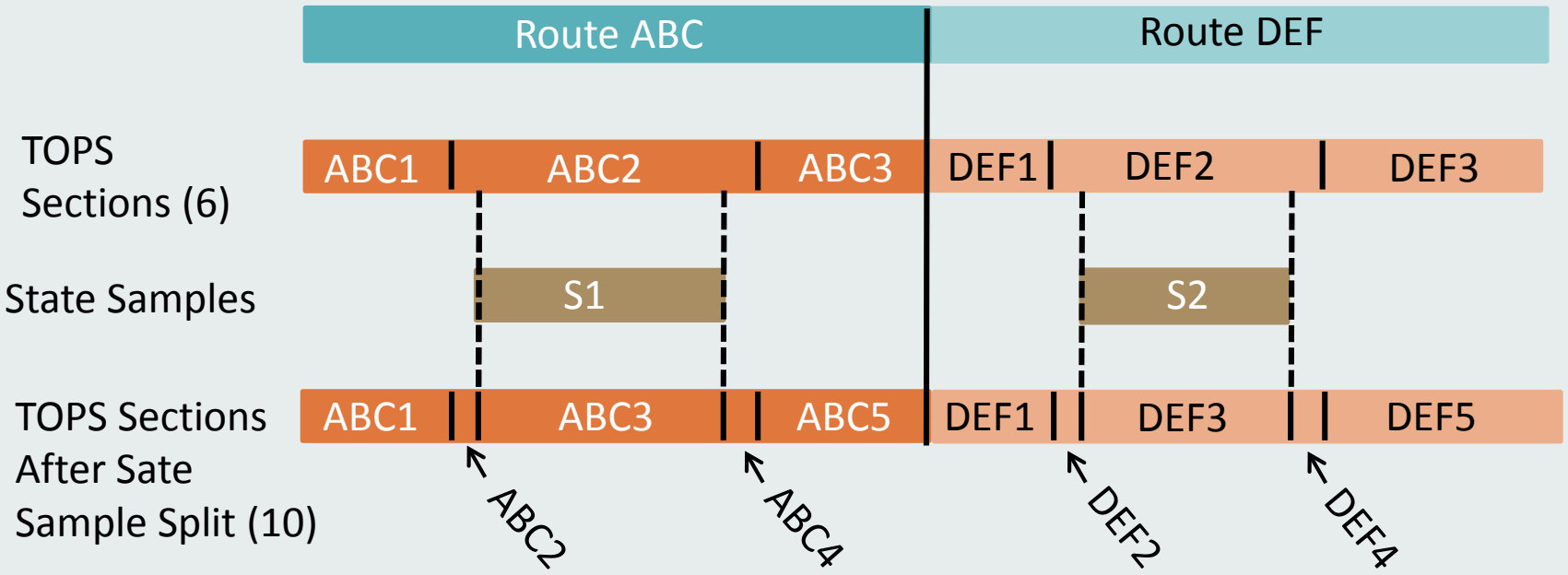
# TOPS Development Process



# TOPS Development Process

Factors Influencing TOPS beyond the 5 TOPS elements:

1. Routes
2. Sample Bounds



# Extent-specific Data Items

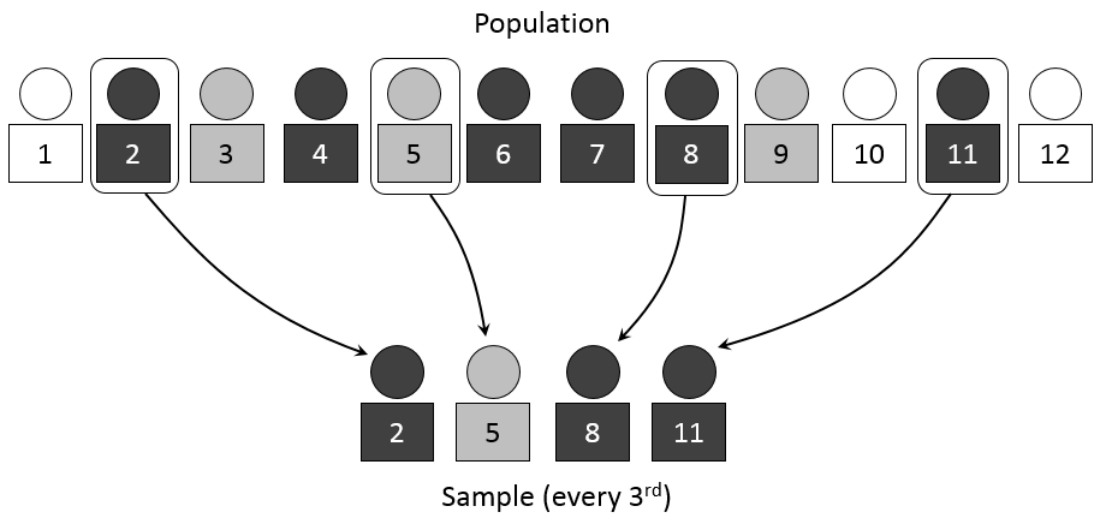
- Number of Signals (Data Item #31)
- Number of Stop Signs (Data Item #32)
- Number of At-Grade Intersections (Data Item #33)
- Curves (Data Item #43)
- Grades (Data Item #45)

# Using the Table of Potential Samples (TOPS)

The TOPS is used for:

- Sample selection purposes
- Sample adequacy assurance

The TOPS will require adjustments when the limits of a TOPS-required data item changes.




Source: https://upload.wikimedia.org/wikipedia/commons/c/c4/Systematic_sampling.PNG

# Questions???

# Lesson Two

AADT Volume Groups, Precision Levels, and Sample Size Estimation Procedure

# AADT Volume Groups and Precision Levels

| Volume Group | AADT Ranges |
|---|---|
| 1 | Under 500 |
| 2 | 500 to 1,999 |
| 3 | 2,000 to 4,999 |
| 4 | 5,000 to 9,999 |
| 5 | 10,000 to 19,999 |
| 6 | 20,000 to 34,999 |
| 7 | 35,000 to 54,999 |
| 8 | 55,000 to 84,999 |
| 9 | 85,000 to 124,999 |
| 10 | 125,000 to 174,999 |
| 11 | 175,000 to 249,999 |
| 12 | 250,000 and more |

- AADT data is stratified into 12 volume groups
- Used for all sampled functional systems (excludes Rural Minor Collector and Local systems)
- Stratification is used for expanding sample data items based on AADT ranges

# Definition of Precision Levels

"The degree of accuracy resulting from the use of a statistical sample"

Example:

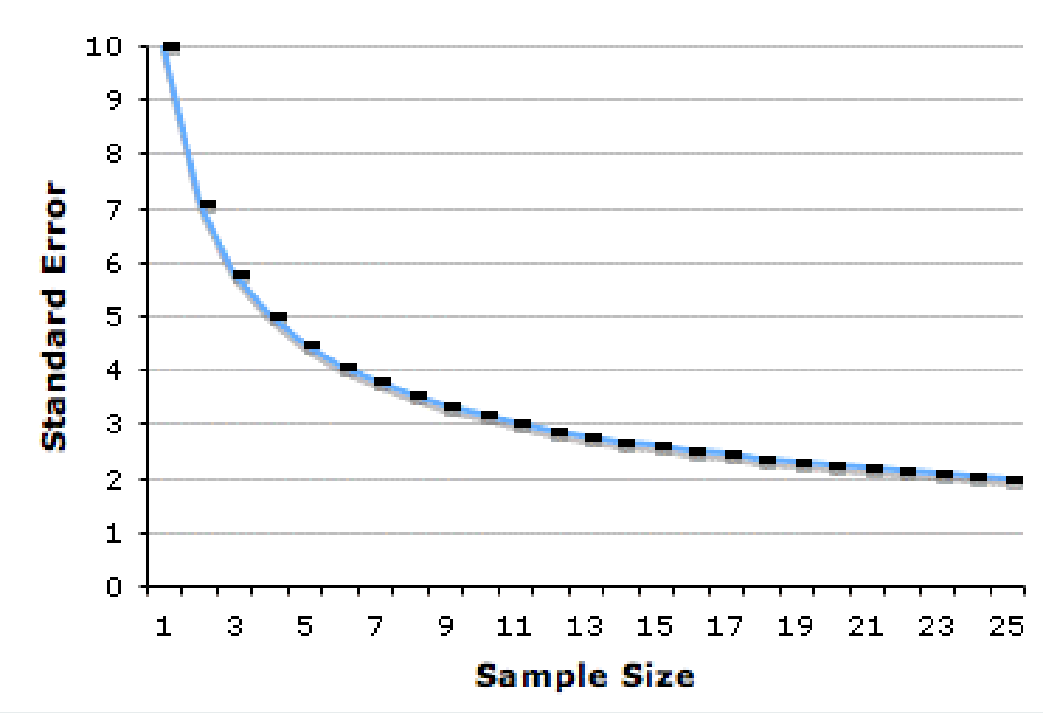
An 80-10 confidence interval and precision level indicates that the sample estimate will be within 10 ± percent of the true value, 80 percent of the time

# Precision Levels by Functional System and Area Type

| | Interstate | Other Freeways and Expressways | Other Principal Arterial | Minor Arterial | Major Collector | Minor Collector |
|---|---|---|---|---|---|---|
| RURAL | 90-5 | 90-5 | 90-5 | 90-10 | 80-10 | – |
| SMALL URBAN | 90-5 | 90-5 | 90-5 | 90-10 | 80-10 | 80-10 |
| URBANIZED < 200,000 population | 80-10 | 80-10 | 80-10 | 80-10 or 70-15* | 80-10 or 70-15* | 80-10 or 70-15* |
| URBANIZED ≥ 200,000 population | 90-10 | 90-10 | 90-10 | 90-10 | 80-10 | 80-10 |

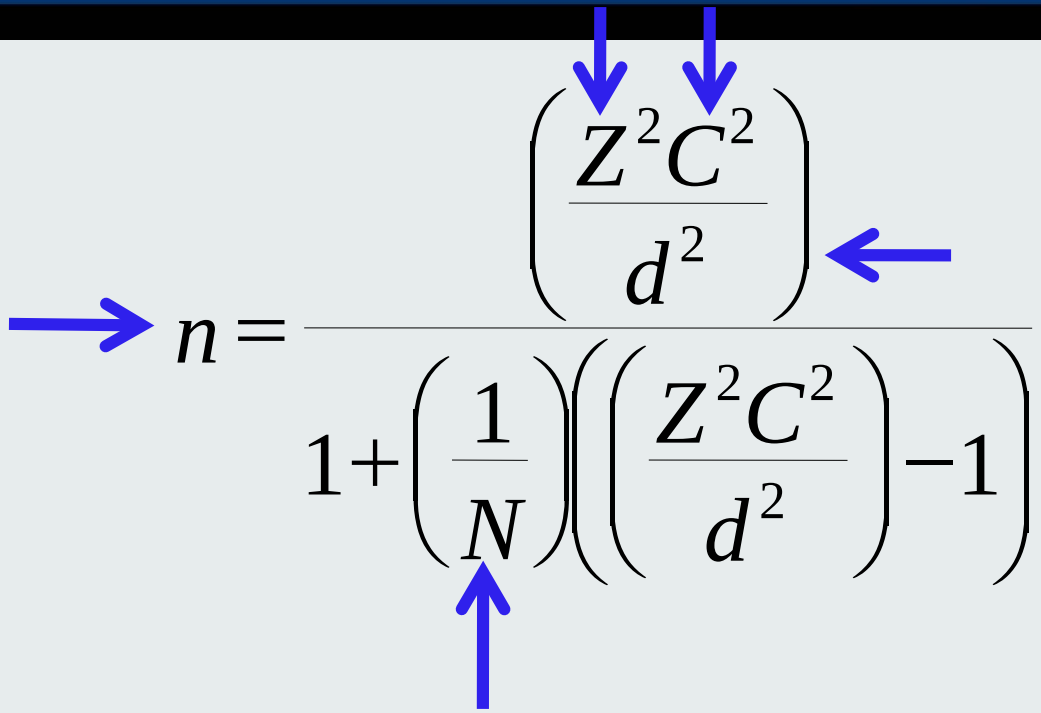
*These precision levels will be applied if a State has three or more urbanized areas with a population < 200,000.

# Sample Size Estimation Procedure




http://davidmlane.com/hyperstat/pictures/sampling_dist8.GIF

# Sample Size Estimation Formula




Where: ***n*** = number of required samples

**Z** = value of the standard normal statistic

**C** = AADT coefficient of variation

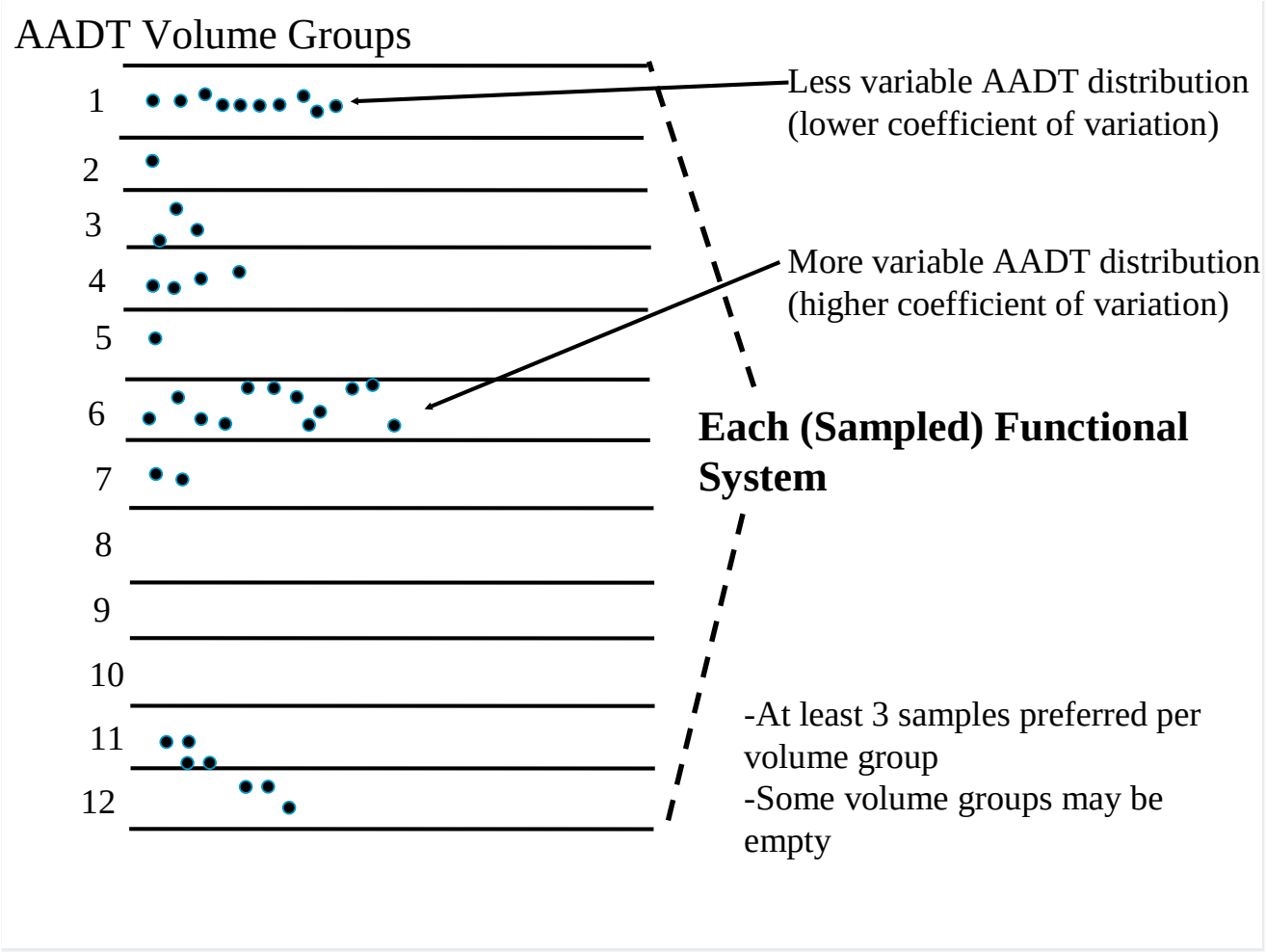
**d** = desired precision rate

**N** = number of available TOPS sections (within a particular volume group)

# Z-values by Confidence Level

| Confidence Level | Value of Z | Z Squared |
|---|---|---|
| 90 Percent | 1.645 | 2.706 |
| 80 Percent | 1.282 | 1.644 |
| 70 Percent | 1.040 | 1.082 |

# AADT Coefficient of Variation (C)



# Sample Size Estimation Example

$$n = \frac{\left(\frac{(1.645)^2(0.4)^2}{(0.05)^2}\right)}{1+\left(\frac{1}{300}\right)\left(\left(\frac{(1.645)^2(0.4)^2}{(0.05)^2}\right)-1\right)} = \frac{173.18}{1+\left(\frac{172.18}{300}\right)} = 110$$

Z = 1.645, standard normal statistic for
90 % confidence level
C = 0.40, coefficient of variation
d = 5%, desired precision rate
N = 300, no. of available TOPS Sections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# Module IV Quiz

1) The term “universe” in the context of HPMS refers to which of the following?

a. All sample sections
b. Federal-aid system
c. State-owned roads only
d. Both b and c

# Module IV Quiz

2) Which of the following represents the sampling units in HPMS?

a. NHS sections
b. Sample sections
c. Universe (i.e. Full Extent of all public roads)
d. None of the above

# Module IV Quiz

3) The Table of Potential Samples (TOPS) is a subset of the HPMS Sample Panel.

a. True
b. False

# Module IV Quiz

4) Which data item from the following list is NOT used to develop the TOPS?

a. Facility Type
b. IRI
c. AADT
d. Through Lanes

# Module IV Quiz

5) Which of the following data items is not required to be reported in accordance with the limits of the TOPS sections?

a. Number of Signals
b. Number of Stop Signs
c. Curve Class
d. None of the above

# Module IV Quiz

6) Which of the following data items must be reported in accordance with the limits of the TOPS sections?

a. Grade Class
b. Percent Green Time
c. Number of Stop Signs
d. Both a and c

# Module IV Quiz

7) The TOPS may require adjustments when:

a. There is a change in the limits of any TOPS-required data item record
b. There is a change in the value associated with a TOPS-required data item record
c. There is a change in the value associated with all TOPS-required data item records
d. Both a and b

# Module IV Quiz

8) In most cases, it is not necessary for the Sections data to be reported in accordance with the limits contained in the Sample Panel ID dataset.

a. True
b. False

# Module IV Quiz

9) Which of the following variables is not used to calculate the number of required samples?

a. Desired Precision Rate
b. System Length
c. Number of available TOPS sections
d. Confidence Interval

# Questions???