Building it right

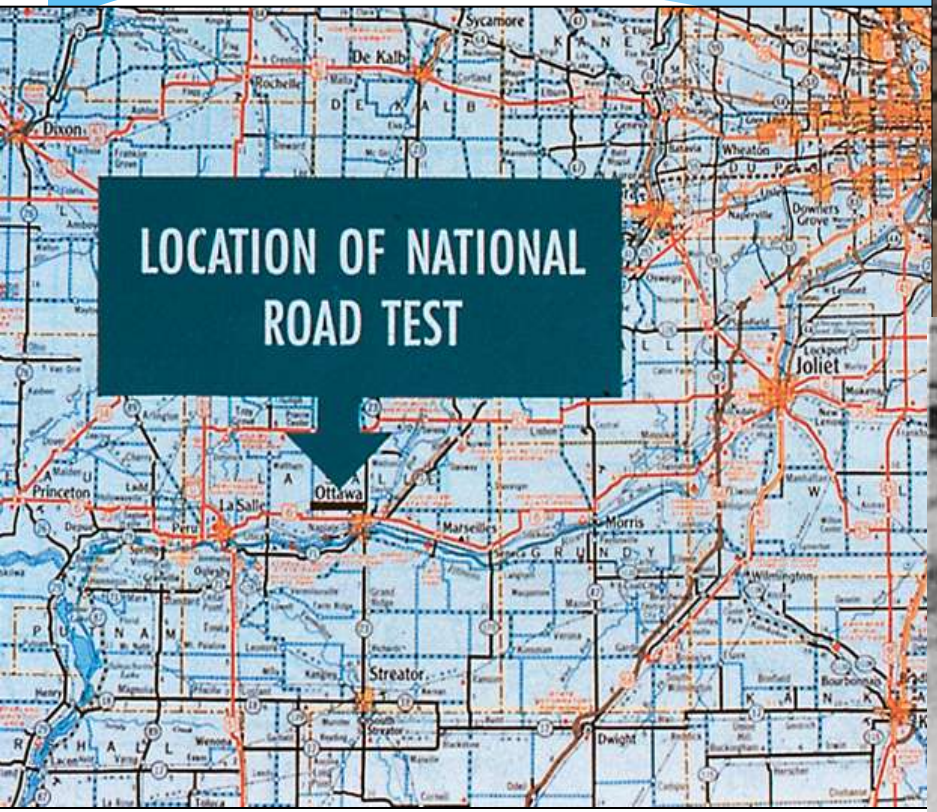
Dennis Dvorak
FHWA Resource Center

WAPA Annual Conference
December 4, 2013

U.S. Department of Transportation
Federal Highway Administration

What does Medieval Times have in common with Asphalt Sampling and Testing?

AASHO Road Test



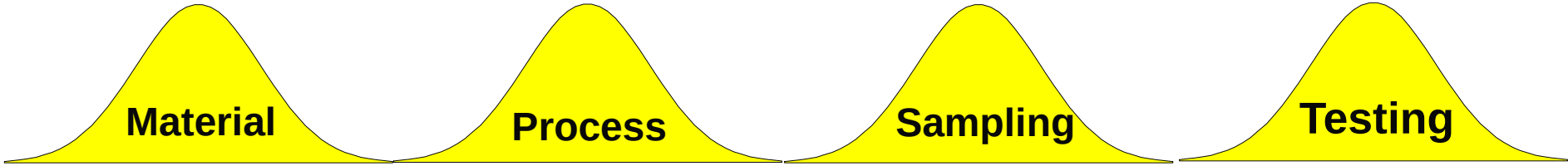
Construction

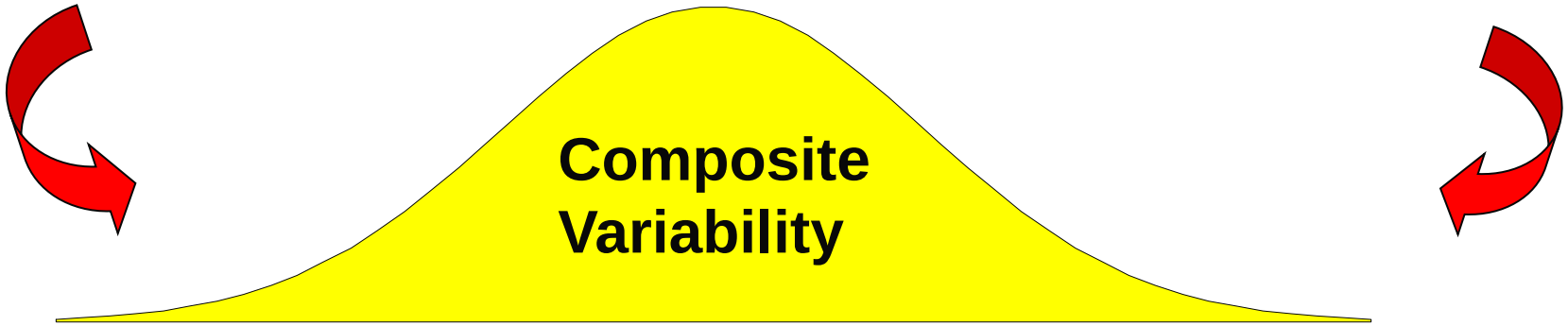
1956 to 1958
Highly controlled
Specifications based on prevailing State DOT practices

Asphalt Paving

Sources of Variability

Material Process Sampling Testing





Core Elements of a Quality Assurance Program

Average

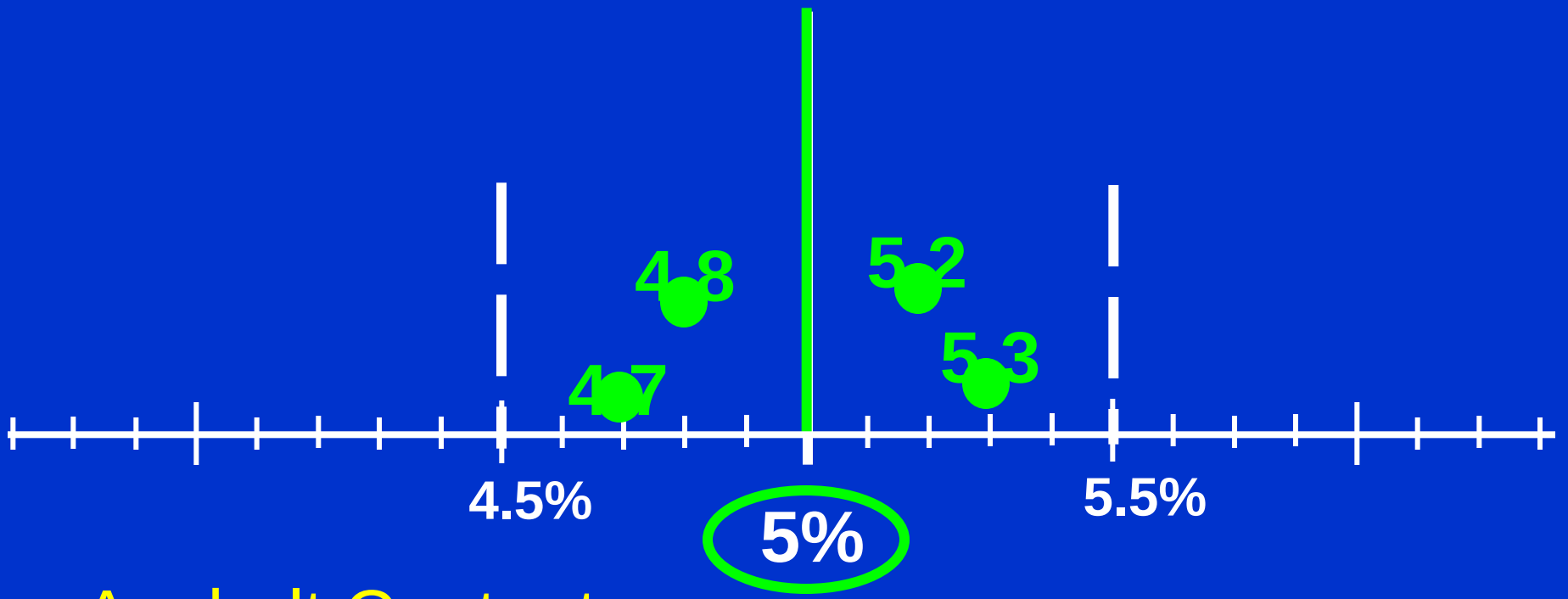
$$\bar{x} = \frac{\sum x_i}{n}$$

X_i = individual test value

n = total number of test values

Example of Using Average

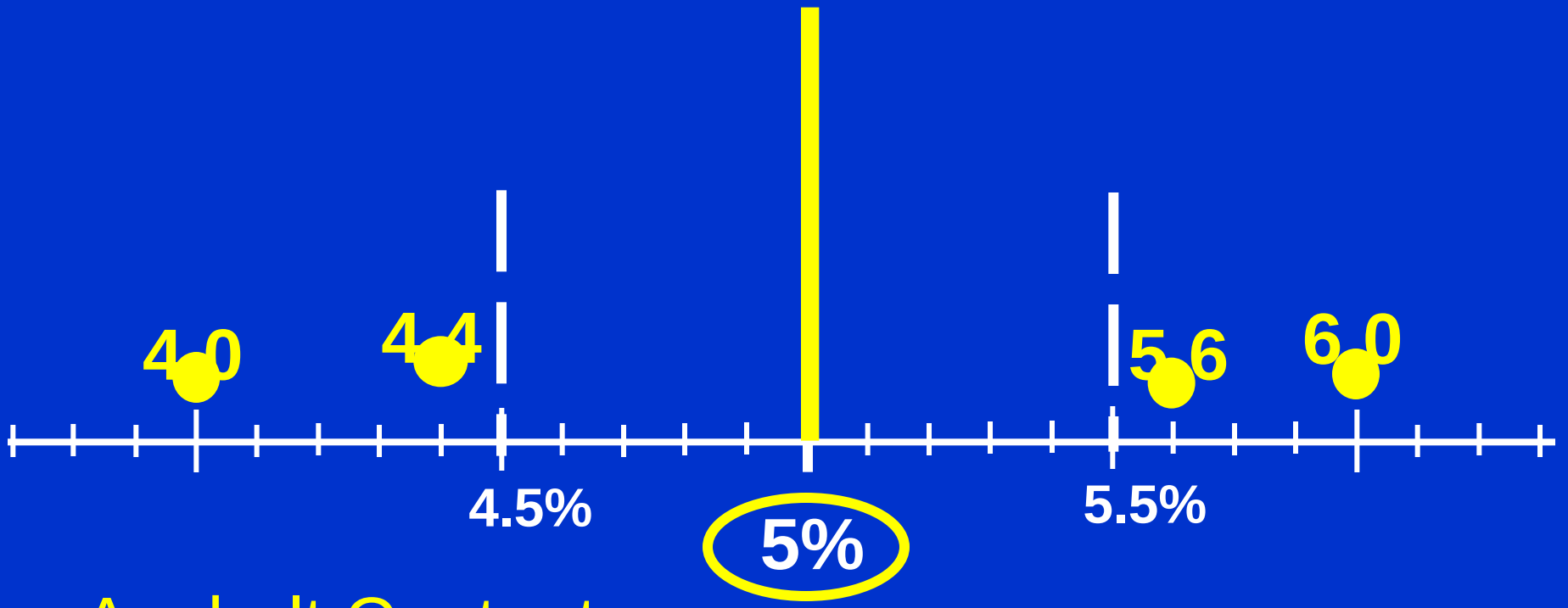
$$\frac{4.7 + 4.8 + 5.2 + 5.3}{4} = 5$$



Asphalt Content

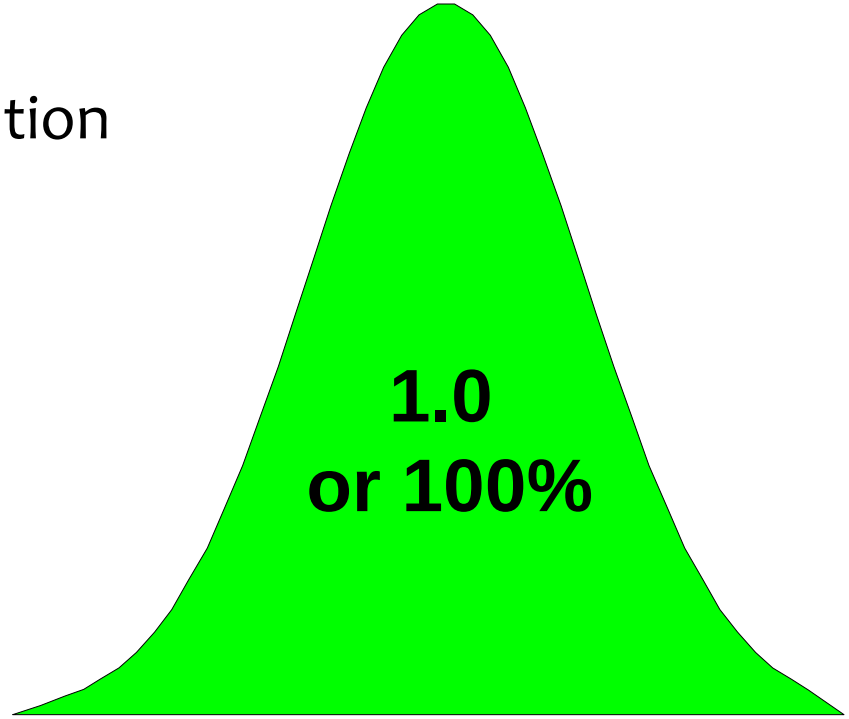
Disadvantage of Using Average

$$\frac{4.7 + 4.8 + 5.2 + 5.3}{4} = 5 \qquad \frac{4 + 4.4 + 5.6 + 6}{4} = 5$$



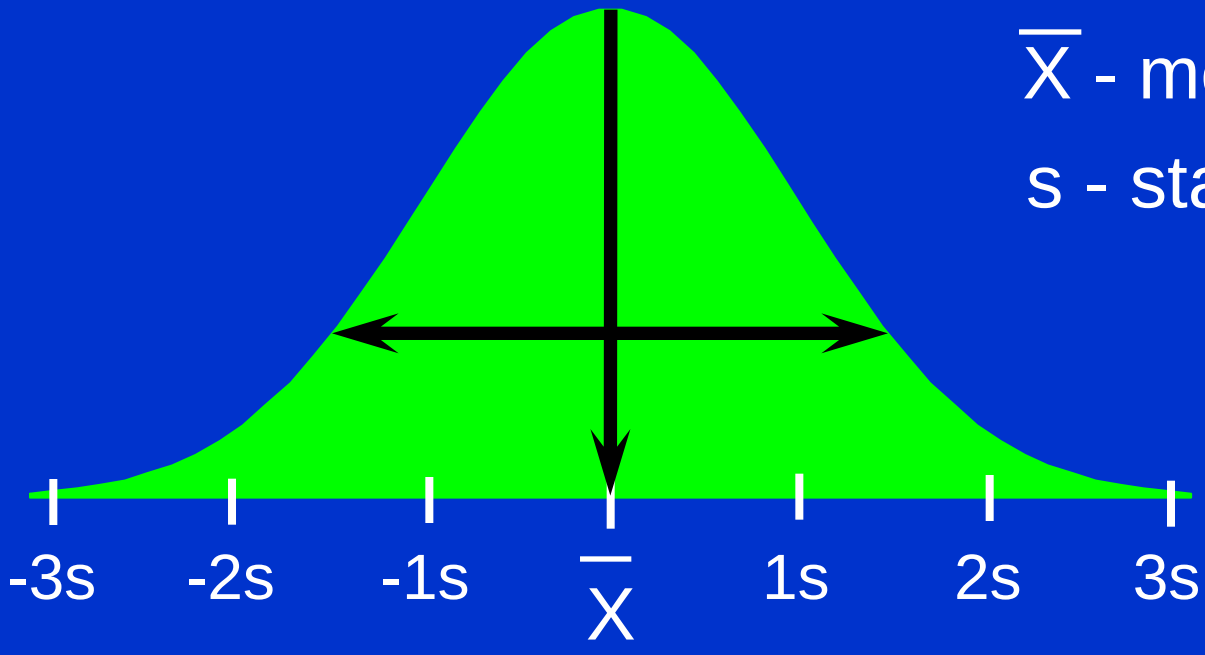
Percent Within Limits (PWL)

* Estimates the percentage of material within specification limits
  * Assumes normal distribution
  * Area equals 1.0 or 100%



PWL

- Efficiently captures mean and standard deviation in one quality measure



$\overline{X}$ - mean

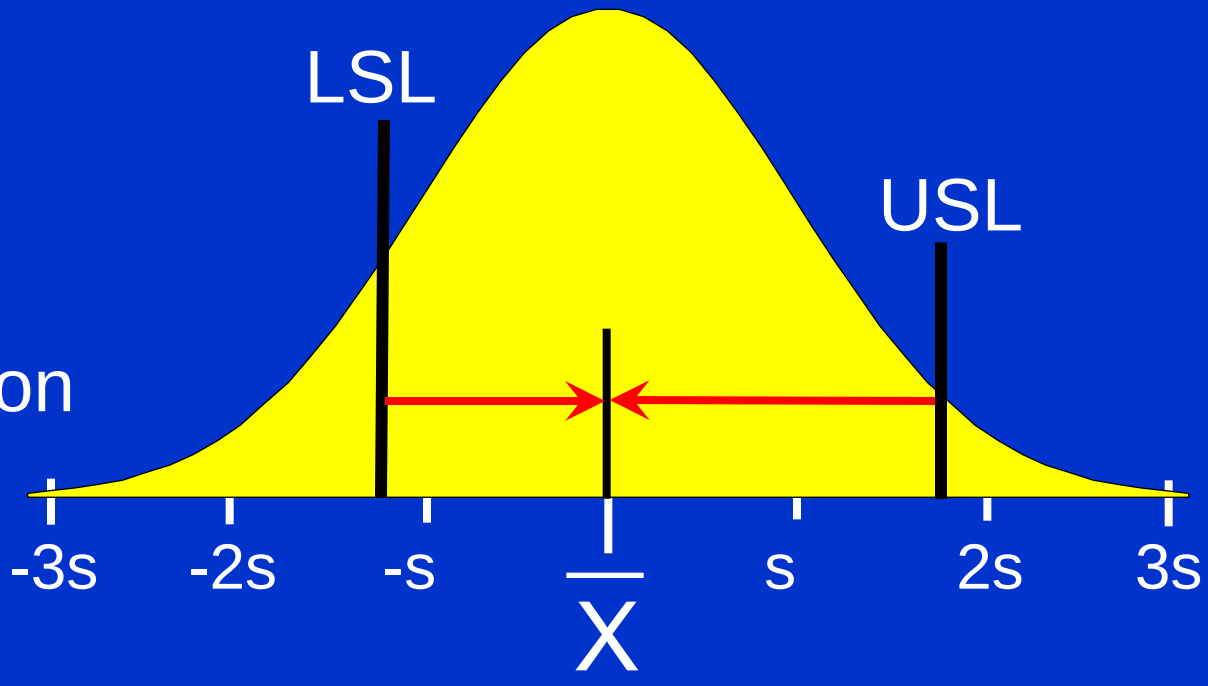
s - standard deviation

PWL

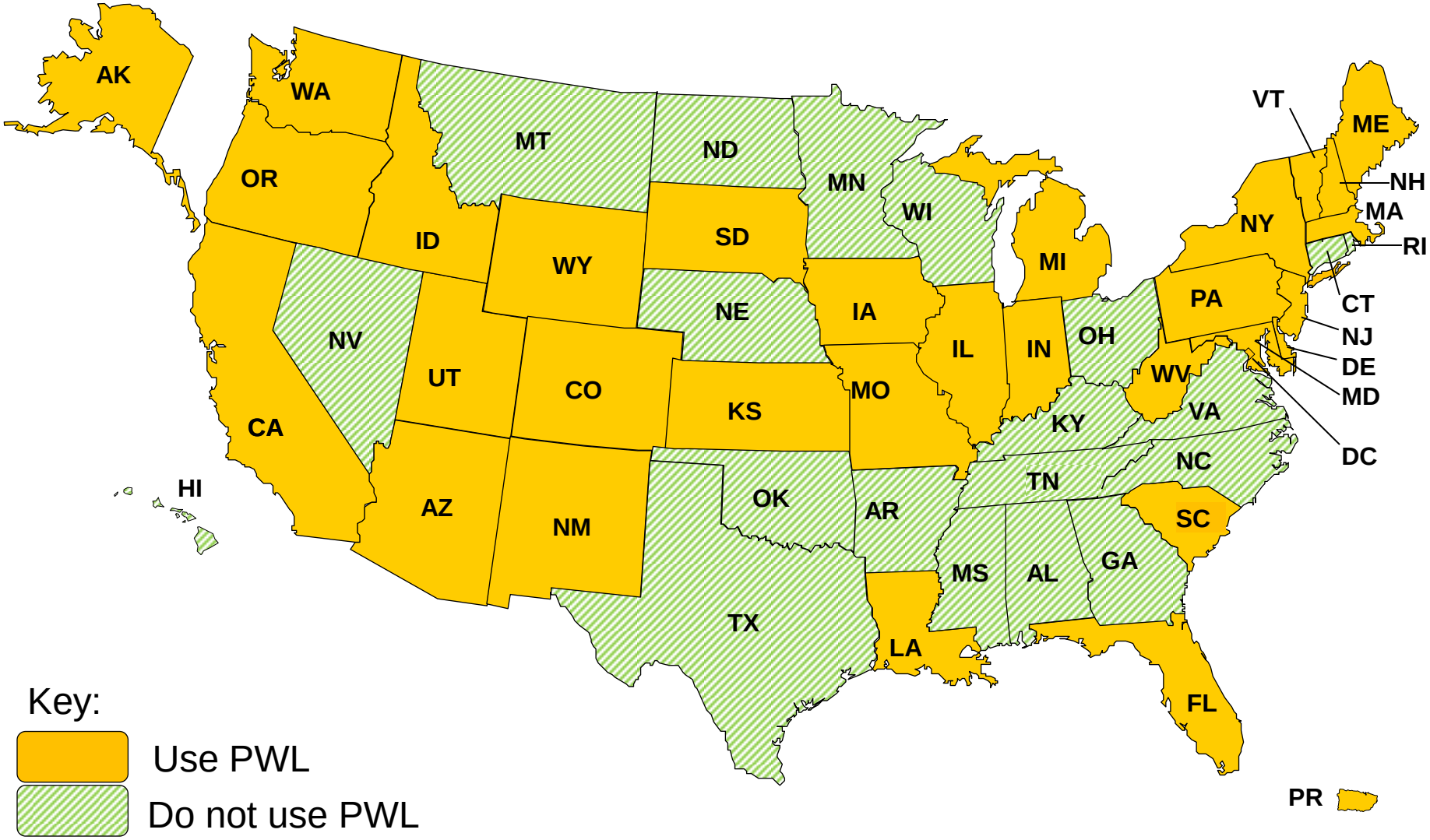
$$Q_U = \frac{USL - \overline{X}}{s}$$

$\overline{X}$ - mean

s - standard deviation



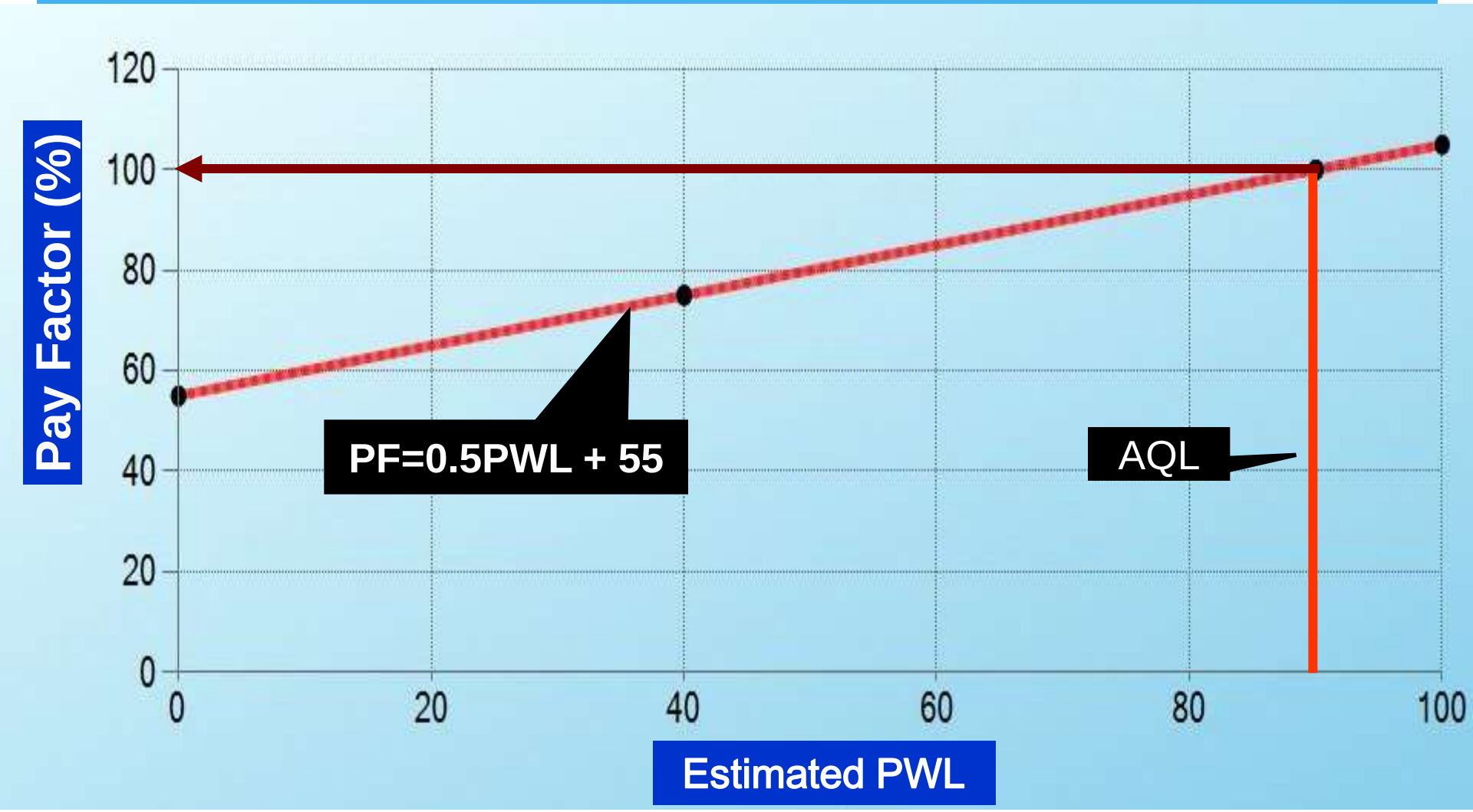
31 States use PWL for Asphalt Pavement



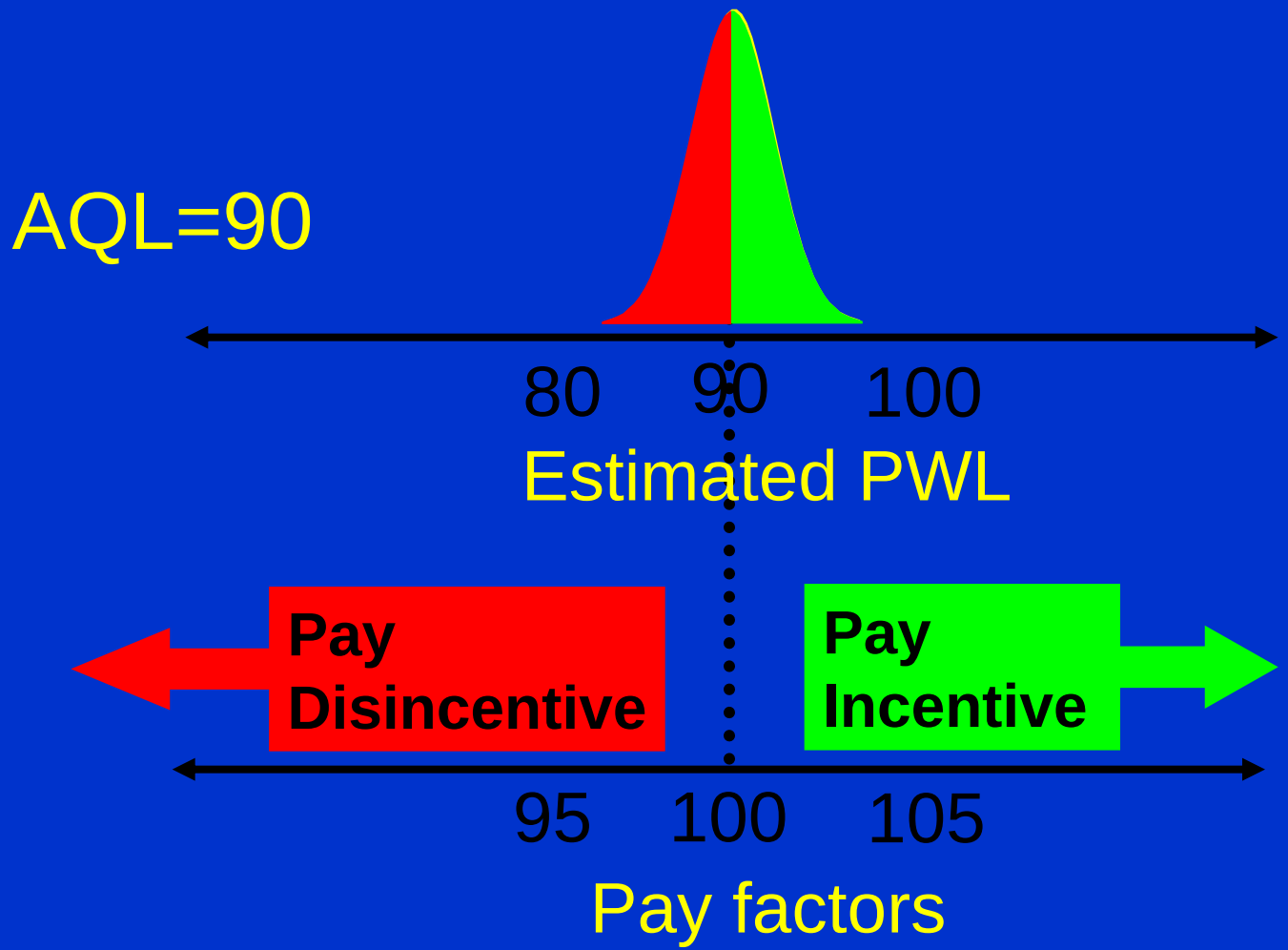
Why Incentives?

* Motivate contractors to improve quality
  * Fairness
  * Positive approach
  * Factor into bidding
* Differentiate contractors that produce "desirable" and "undesirable" quality work
* When incentives are included, they should be sufficient to encourage contractor innovation

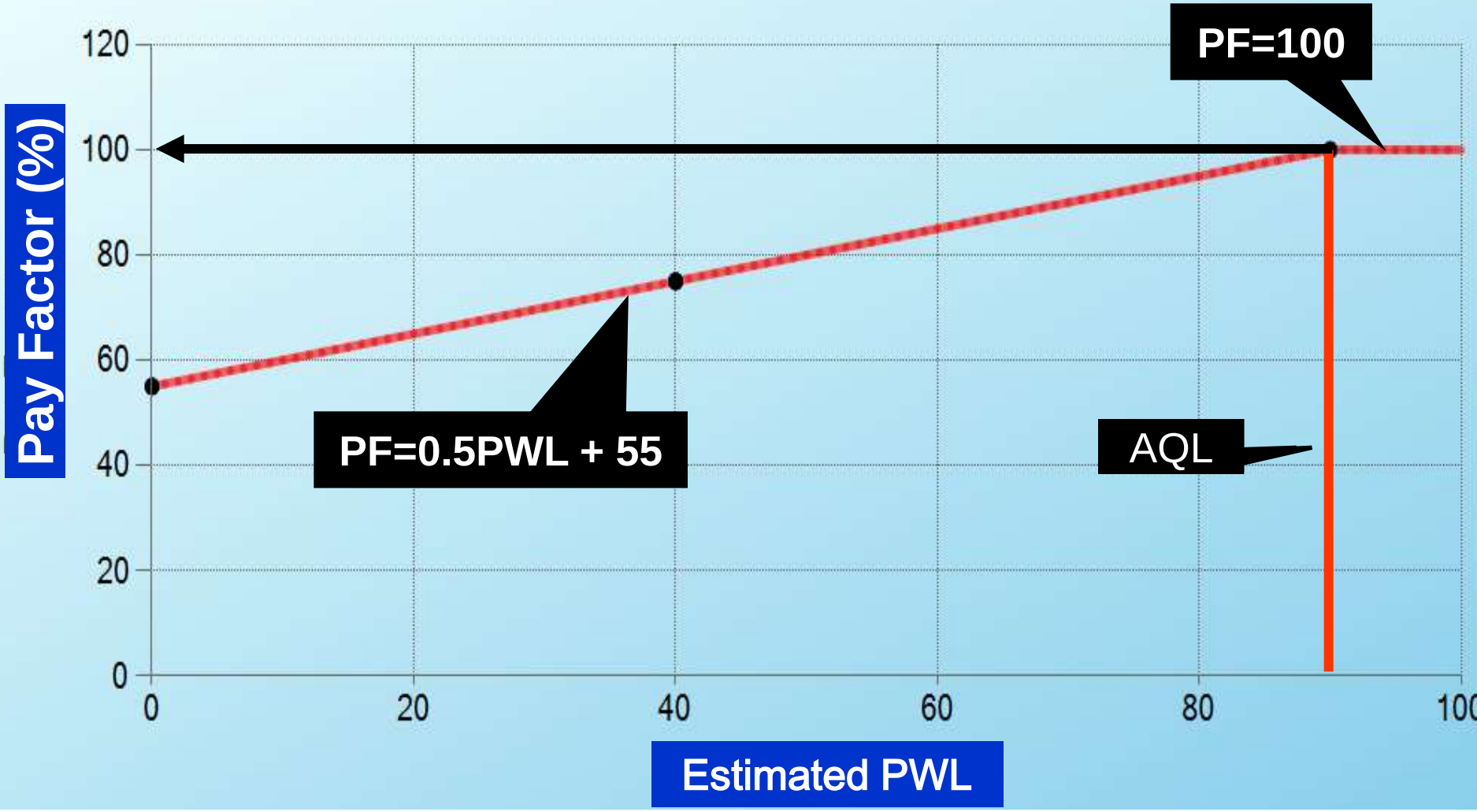
Payment Plan with 5% Incentive



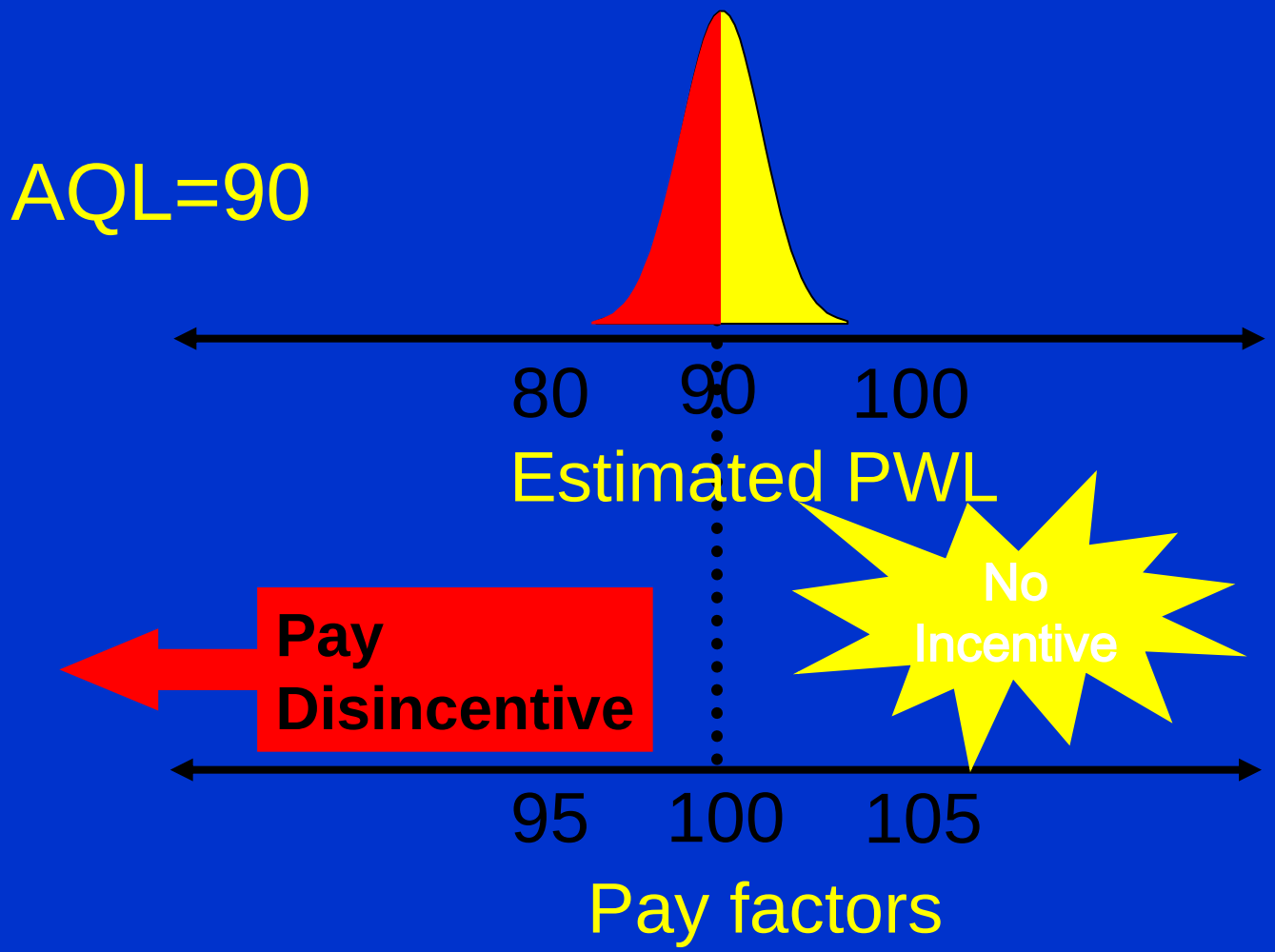
Payment Plan with Incentive



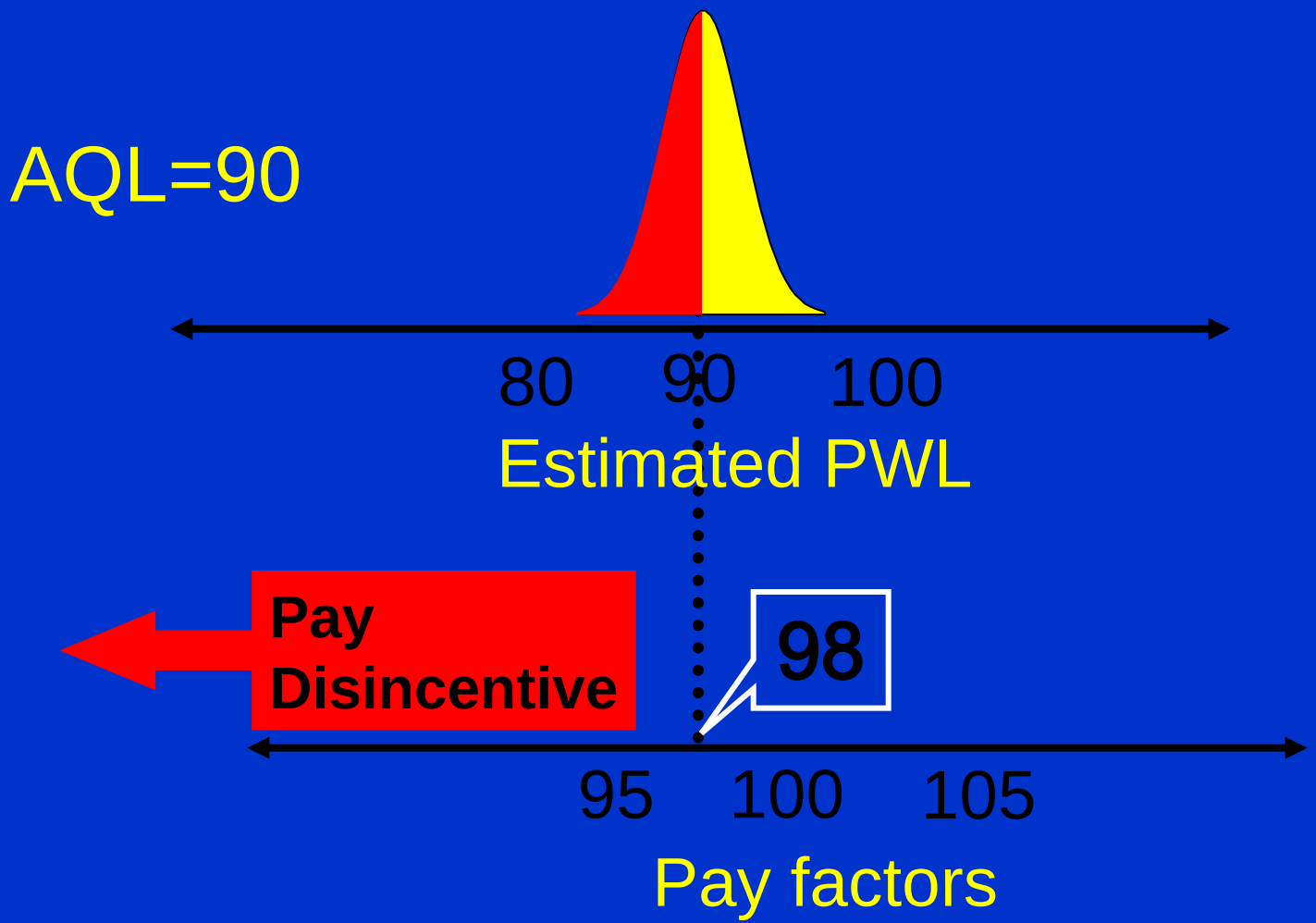
Payment Plan without Incentive



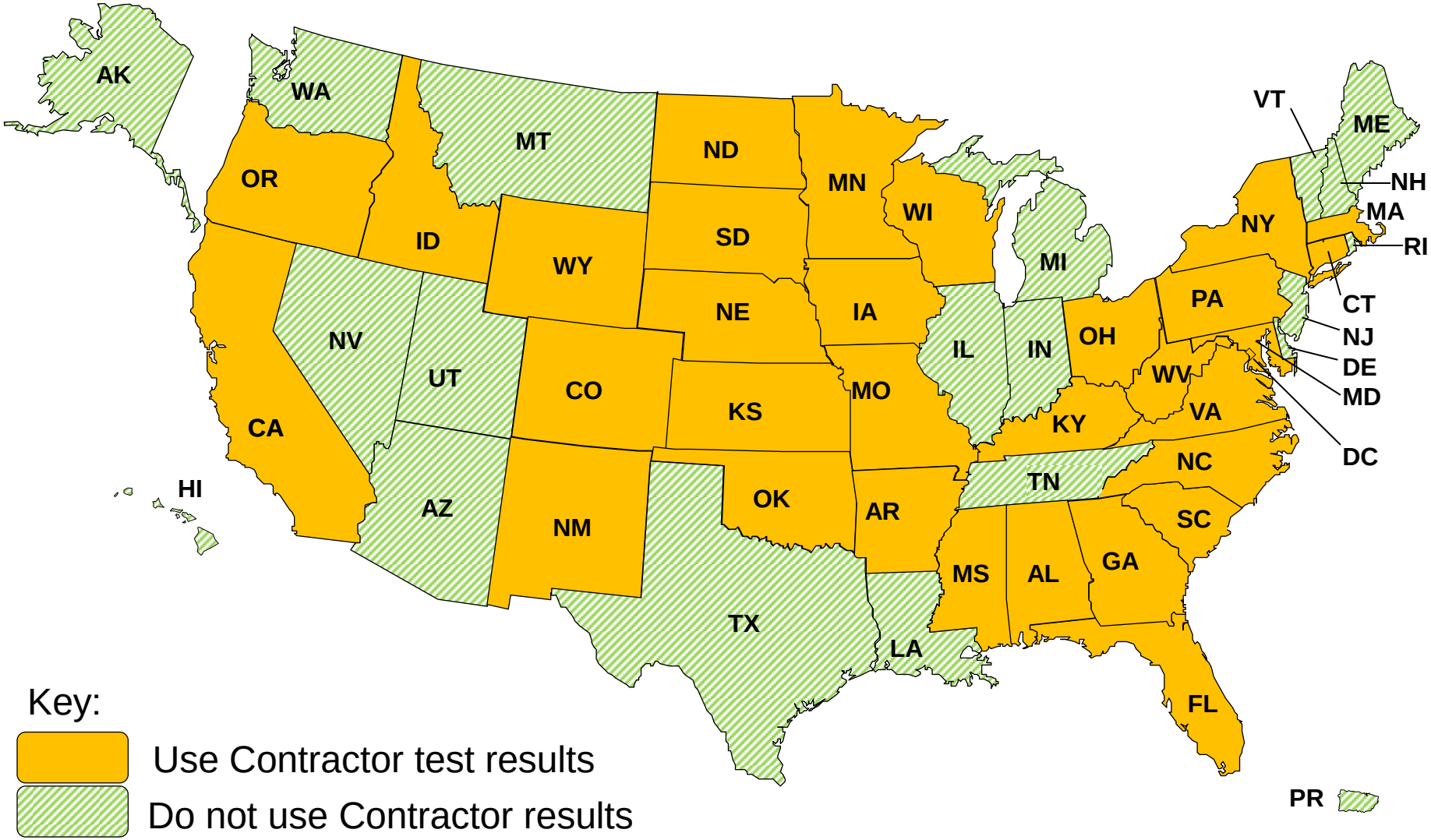
Payment Plan without Incentive



Payment Plan without Incentive



31 States use Contractor test results in the Acceptance Decision



Split Sample Correlation Approaches

- The manner of comparison may be either one of the following:
  - AASHTO D2S precision statements
  - Owner-determined comparison

Validating QC Data Used in an Acceptance Determination

23 CFR 637

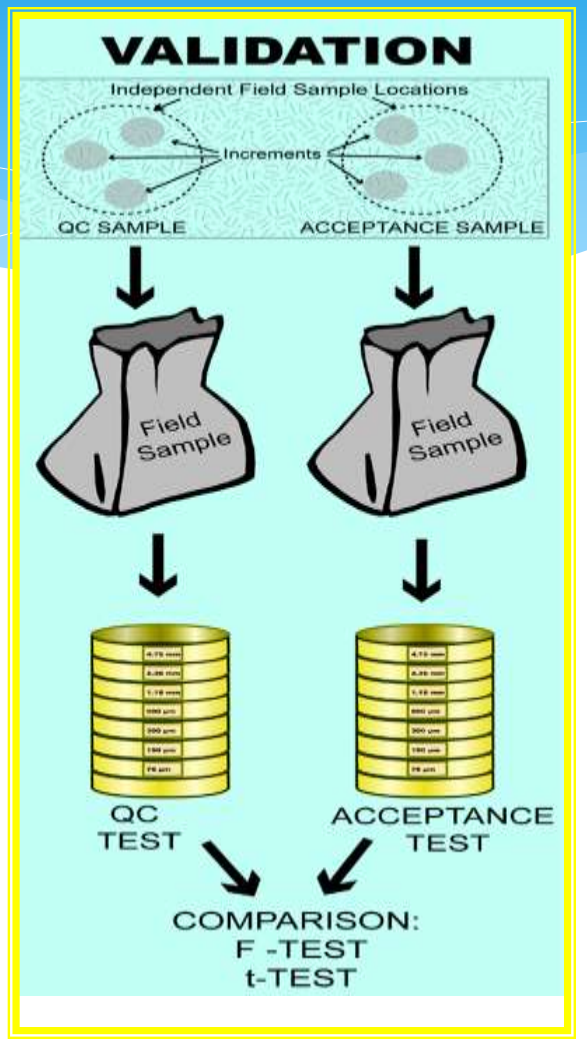
- 23CFR637B Sec. 637.207 QA Program
- Contractor sampling and test results can be used as part of the acceptance decision provided:
- (a)(1)(ii)(B) … they are validated by verification sampling and testing … verification testing shall be performed on samples taken independently of the contractor samples

Validation

The mathematical comparison of two independently obtained sets of data to determine whether it can be assumed they came from the same population

Validation

- When comparing the two data sets for validation:
  - It is important to compare both the means and the variances
  - A different test is used for each of these properties
- Can identify differences in test results that can result in significant difference in payment



Statistical Tests Used for Validation

- Two Tests
  - F-test compares variances
  - T-tests compare means

Conducting the F- and t-tests

- Statistical tests are conducted at a selected level of significance, alpha (α)
  - Recommended range is between .01 and .05

If 0.025 is used and the null hypothesis is rejected, then there is only 1 chance in 40 that null hypothesis is true and was rejected in error ("false alarm")

Conducting the F- and t-tests

These tests can identify a *difference…*

but not a *cause*

Power of the *F*-test

Ratio of Standard Deviations	Number of Contractor Tests	Number of Agency Tests	Probability of Detecting a Difference
2	3	3	0.10
	5	5	0.21
	20	5	0.49
	⋮	⋮	⋮
	40	10	0.77
	50	15	0.90

Dispute Resolution
23 CFR 637

Dispute Resolution - "The procedure used to resolve conflicts resulting from discrepancies between the Agency's and Contractor's results of sufficient magnitude to impact payment."

Function of Dispute Resolution

* Formal system designed to address significant differences between Qv and QC data
* Dispute Resolution system required when QC results used in Acceptance decision

Responsibility for Dispute Resolution

* Can be performed within the DOT
* Use of accredited third party laboratory can be used.
* The State has custody of material

Questions