Weigh-In-Motion Detection and Load Spectrum Analysis

Southeastern Pavement Management and Design Conference

Nashville, Tennessee

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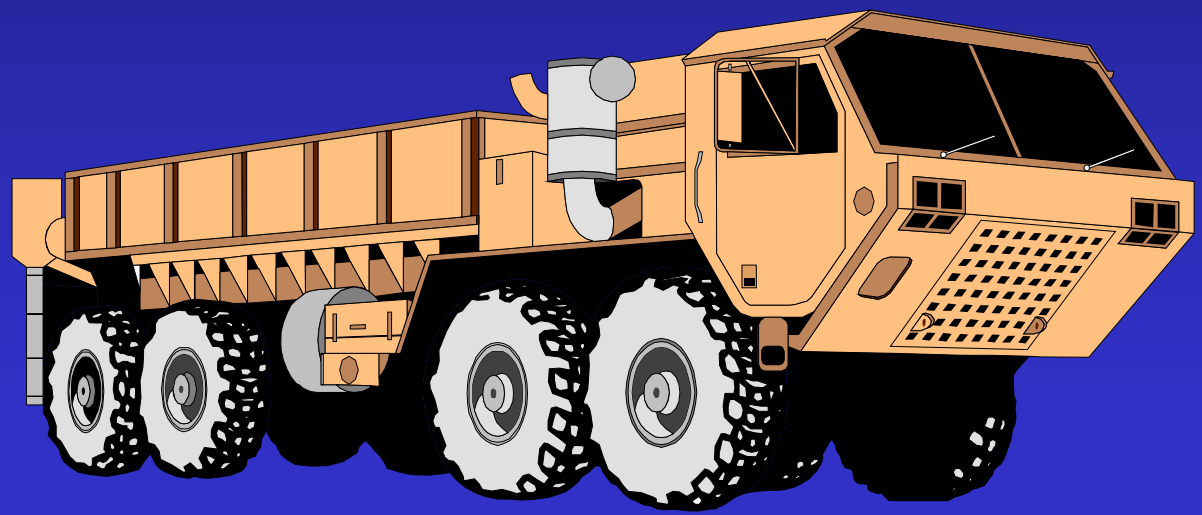
OVERVIEW

- WIM Systems
- Successful WIM Implementation
- Axle Load Spectra



WEIGHT-IN-MOTION

"the *process* **of** *measuring* **dynamic tire forces of a** *moving* **vehicle and** *estimating* **the corresponding tire loads of the** *static* **vehicle"**

- ASTM E 1318-02

ASTM E 1318-02

- Purpose-to aid the user and vendor in specifying, purchasing, installing and testing a WIM system.
- Requires User to provide smooth, durable pavement structure, in good condition.
- Trucks should be moving at constant speed in their travel lanes when crossing the sensors.

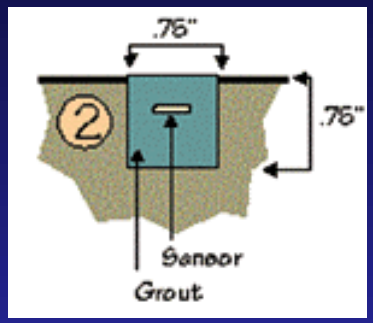
ASTM WIM CLASSIFICATION

WIM System	Speed Range	Application	Number of Lanes
Type I	16 – 130 km/h (10 – 80 mph)	Traffic Data Collection	Up to 4
Type II	16 – 130 km/h (10 – 80 mph)	Traffic Data Collection	Up to 4
Type III	16 – 130 km/h (10 – 80 mph)	Weight Enforcement	Up to 2
Type IV	3 – 16 km/h (2 – 10 mph)	Weight Enforcement	Up to 2

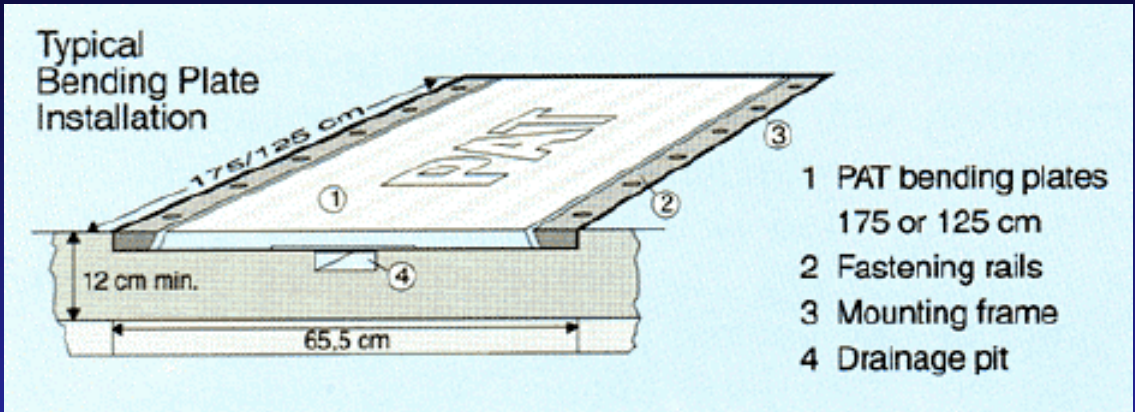
TYPES OF WIM EQUIPMENT

- Piezoelectric Sensors
- Bending Plate Scale
- Deep Pit Load Cell

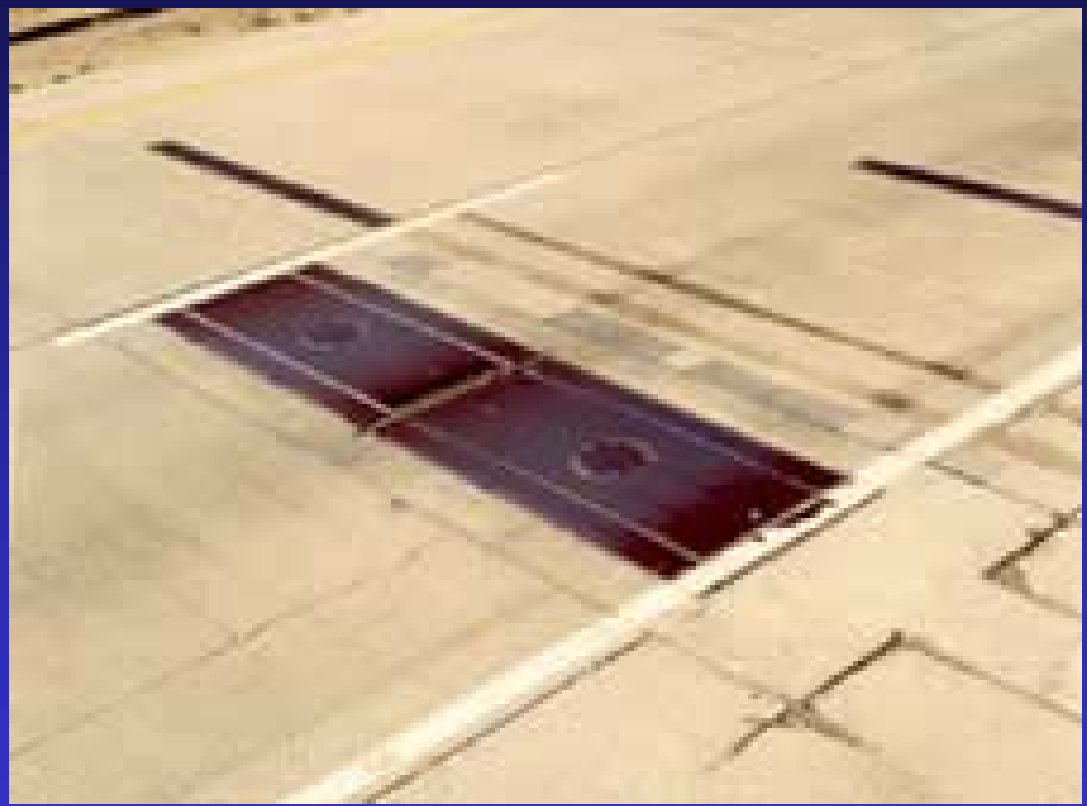
PIEZOELECTRIC SENSORS



BENDING PLATE



LOAD CELL



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ess http://www.ornl.gov/dp121/index.htm Go

DP 121 Weigh-in-Motion Technology

Executive Summary

Choosing a WIM System

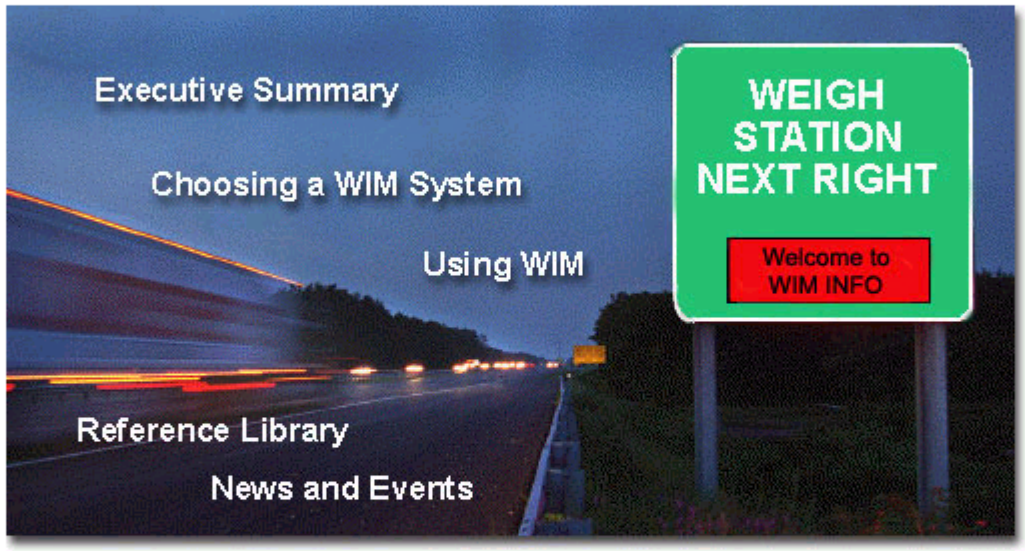
Using WIM

Library

News and Events

Search

Contacts



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COST COMPARISON

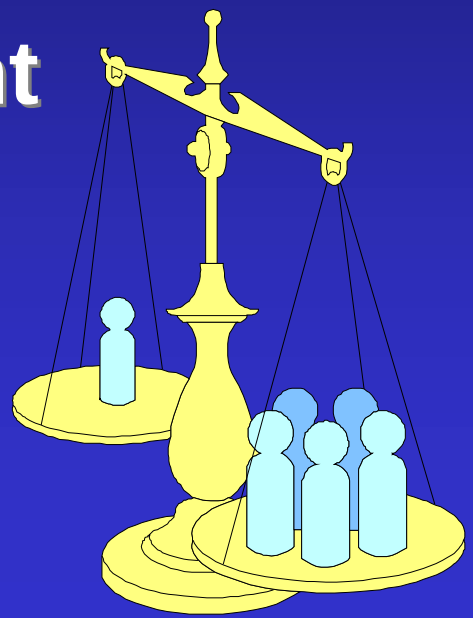
WIM System	% GVW Error – Highway Speeds	Initial Cost *	Maintenance Cost **
Piezoelectric Sensor	+/- 10%	$9,500	$4,224
Bending Plate Scale	+/- 5%	$18,900	$4,990
Double Bending Plate Scale	+/- (3 - 5)%	$35,700	$7,709
Deep Pit Load Cell	+/- 3%	$52,500	$7,296

*Estimated initial cost per lane (equipment and installation)

** Estimated average cost per lane (12-year life span including maintenance)

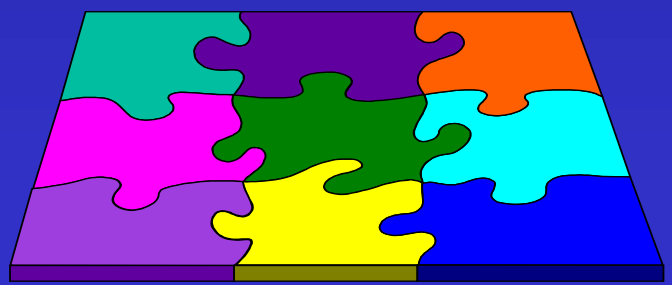
SELECTING WIM EQUIPMENT

- "Site Design Life"
  - Type of Equipment
  - Site Location and Condition
  - Installation of Equipment
- Intended Use of Data
  - Data Analyses
  - Accuracy and Precision



SITE SELECTION

- Geometric Design
  - Horizontal Curvature
  - Roadway Grade
  - Cross Slope
  - Lane Width



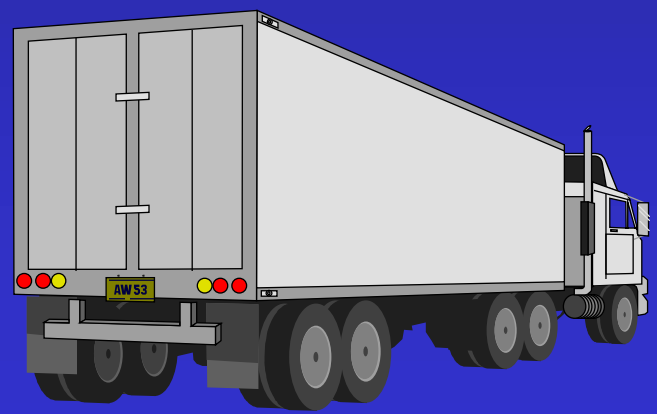
- Pavement Condition
  - Smoothness
  - Deflection
- Site Location
  - Power & Phone
  - Drainage
  - Traffic

SYSTEM CALIBRATION

- Operation Check
  - –Initial Calibration
  - –Continuous Operations Check
- Fine Tuning/Recalibration

MINNESOTA EXAMPLE

- Automatic Recalibration
  - –Front Axle of VC 9 Trucks
  - –Adjustment Factors
  - –Calibration Correction Factor

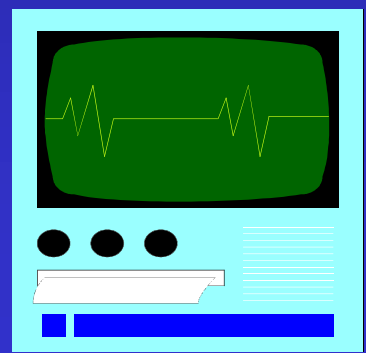


QUALITY ASSURANCE

- Vehicle Counts
- Vehicle Classification
- Weight-In-Motion
  - Gross Vehicle Weight
  - Axle Weight and Spacing
- AVC and WIM Volume and Class Comparison

CALTRANS EXAMPLE

- "Knowledge of Site Characteristics" Review
- "Real Time" Review
- First Level Data Review
  - –Summary Report
  - –Individual Truck Report



CALTRANS EXAMPLE

- Second Level Data Review
  - –WIM Analysis Program
  - –Determine Calibration Adjustments

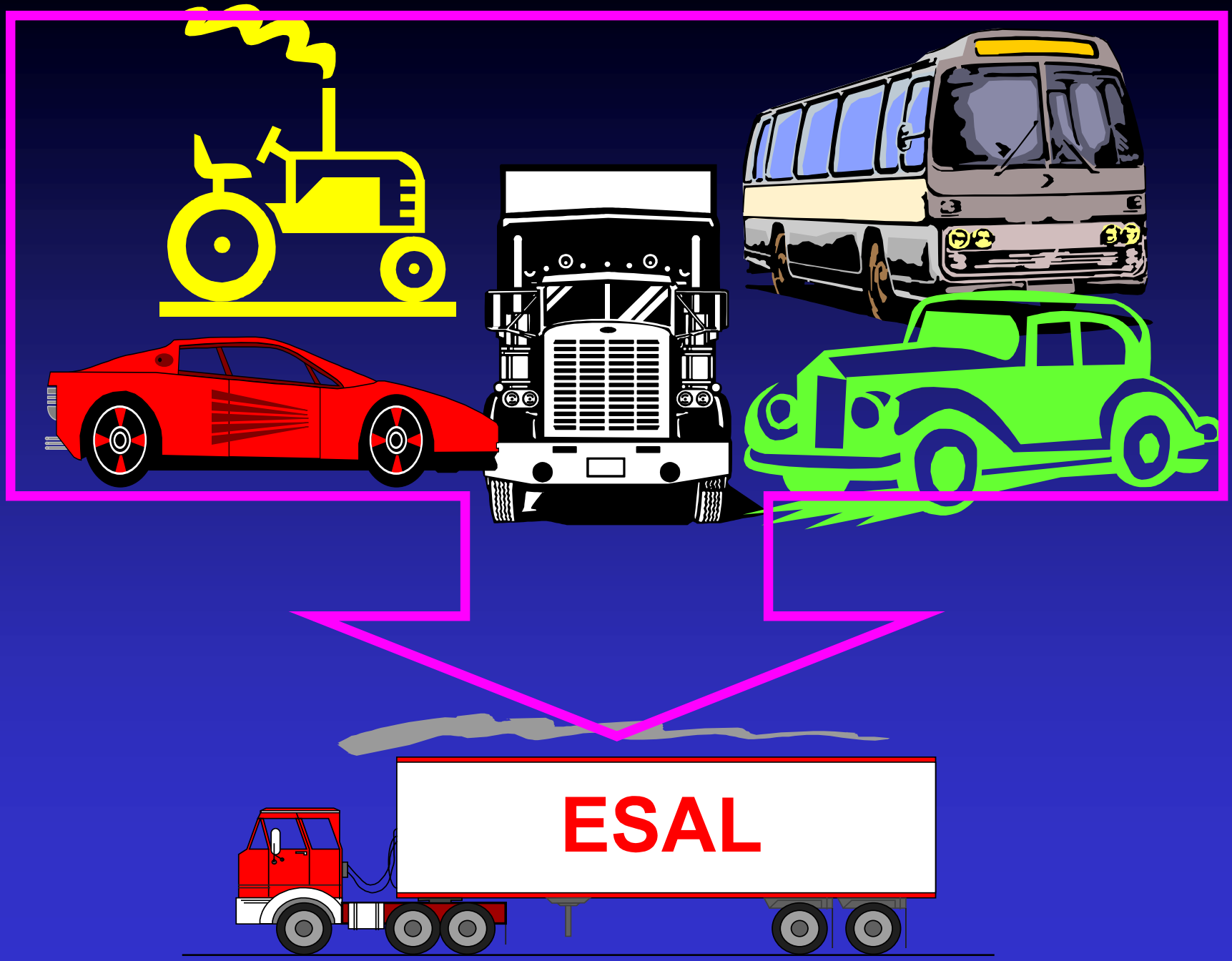
Site Maintenance

- WIM Sensor Operation
- Loop Operation
- WIM Electronics and Equipment
- System Maintenance & Cleaning
- Visual Inspection of Site
- Software Maintenance

ESALS

TRAFFIC – 1993 GUIDE

- Truck Equivalency Factors (TEF)
- Equivalent Single Axle Loads (ESALs)


ESAL

TRUCK EQUIVALENCY FACTOR

AC PAVEMENT
(SN=5, P_t = 2.5)

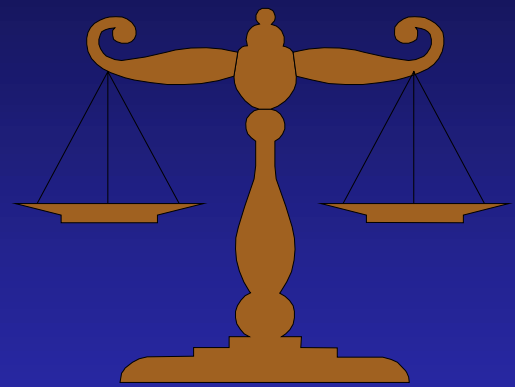
GROSS WEIGHT = 80 k

36 k tandem	36 k tandem	8 k single
LEF = 1.38	LEF = 1.38	LEF = 0.34

TF = 1.38 + 1.38 + 0.34 = 3.10 ESALS/TRUCK

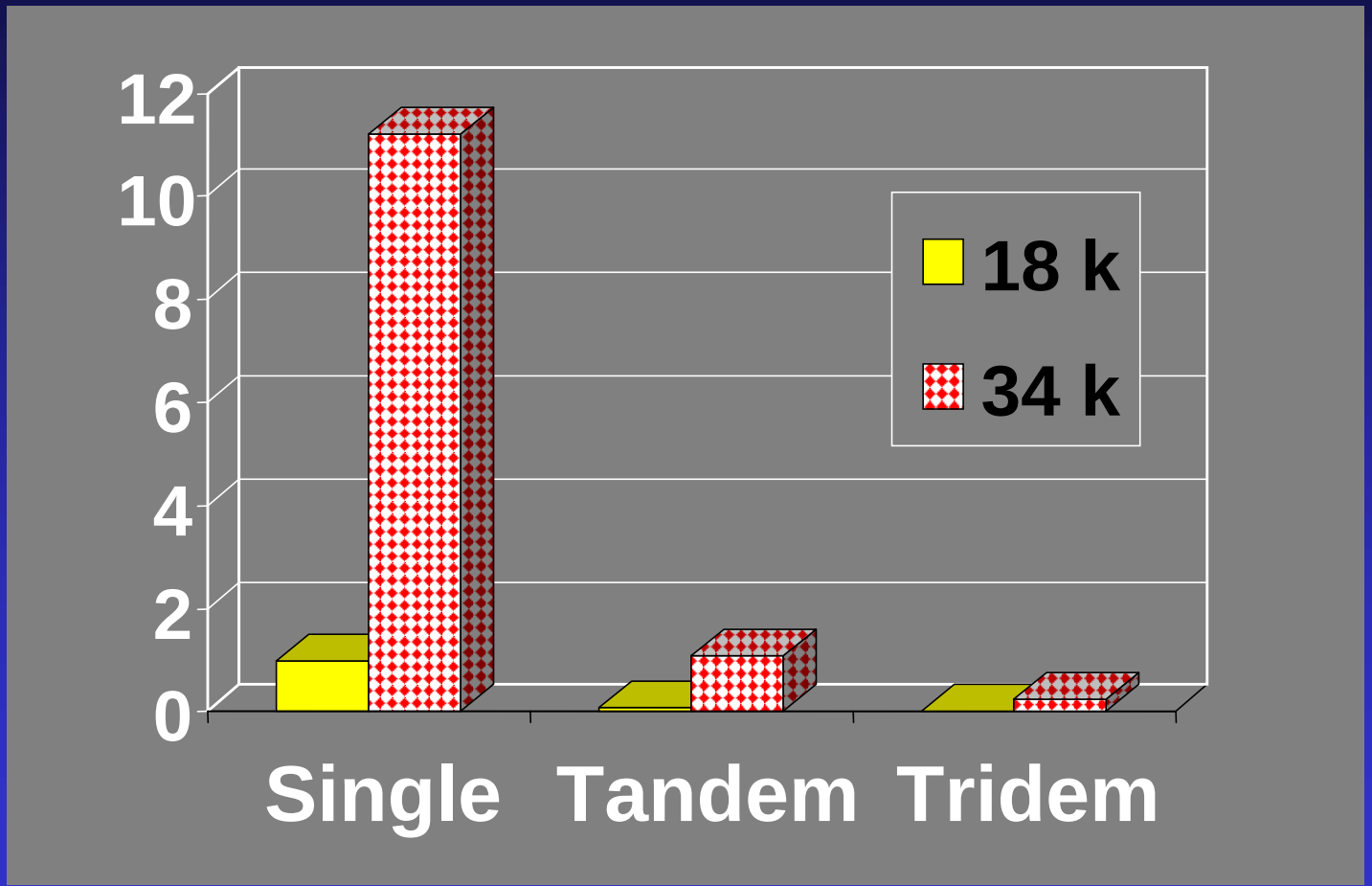
TRUCK EQUIVALENCY FACTORS

- TEF
  - –Pavement Type
    - Flexible & Rigid
  - –Structural Number (SN)
  - –Terminal Serviceability (P_t)



TEF – Flexible

SN = 5 & P_t = 2.5

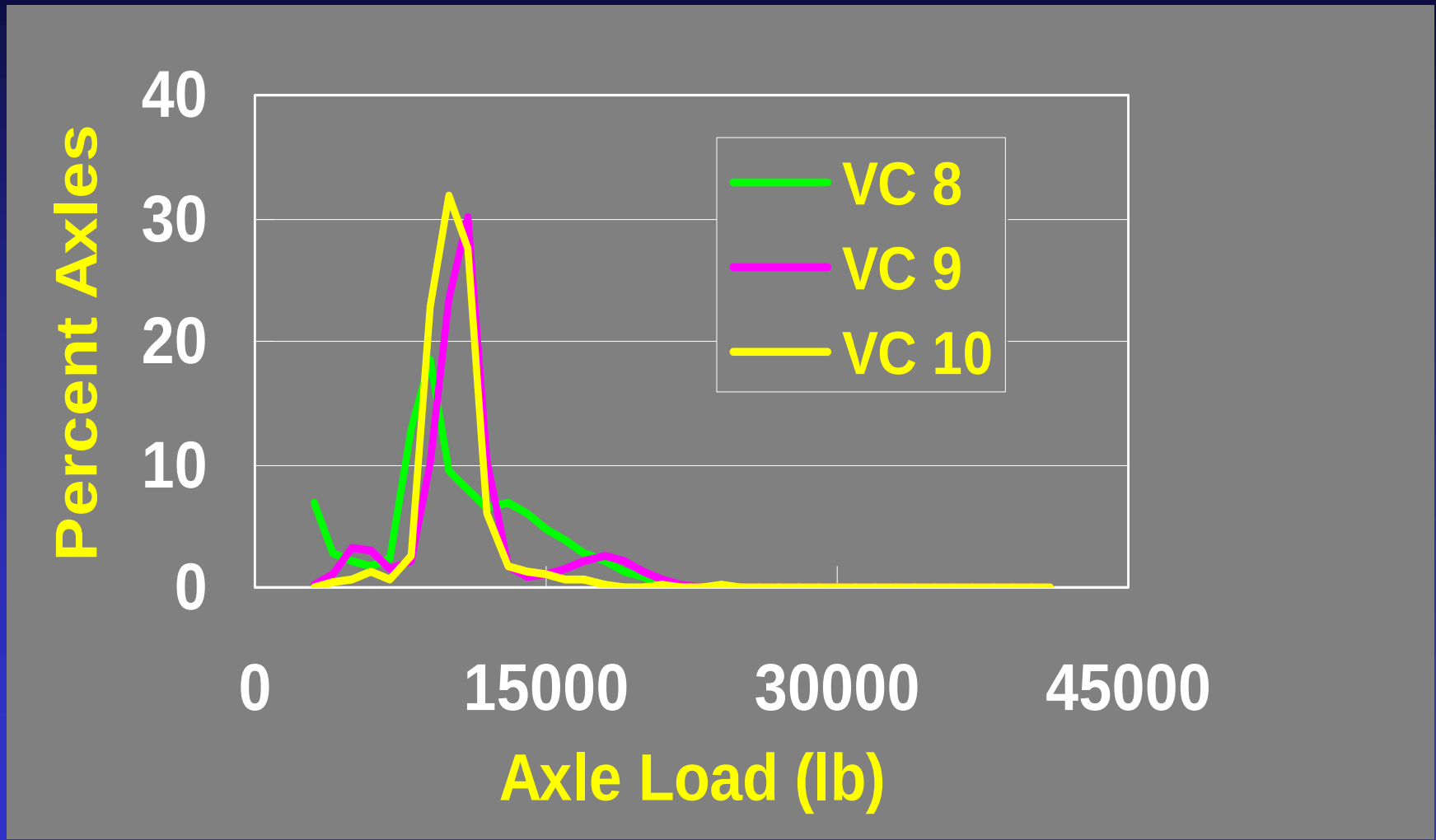


AXLE LOAD SPECTRA

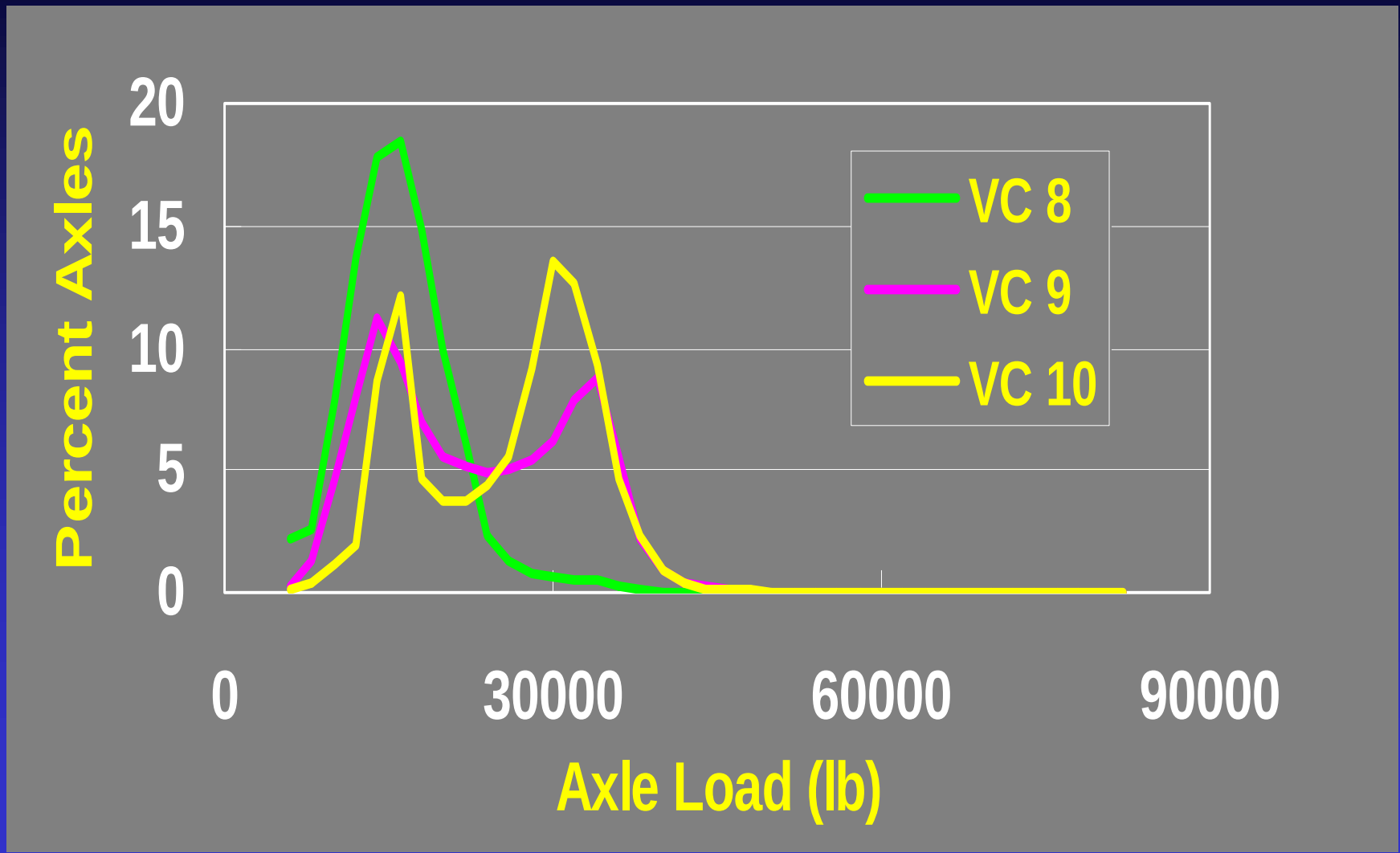
MECHANISTIC DESIGN

- ESALs Not Adequate
- Requires Axle Load Spectra
  - –Same data source
  - –Additional Processing

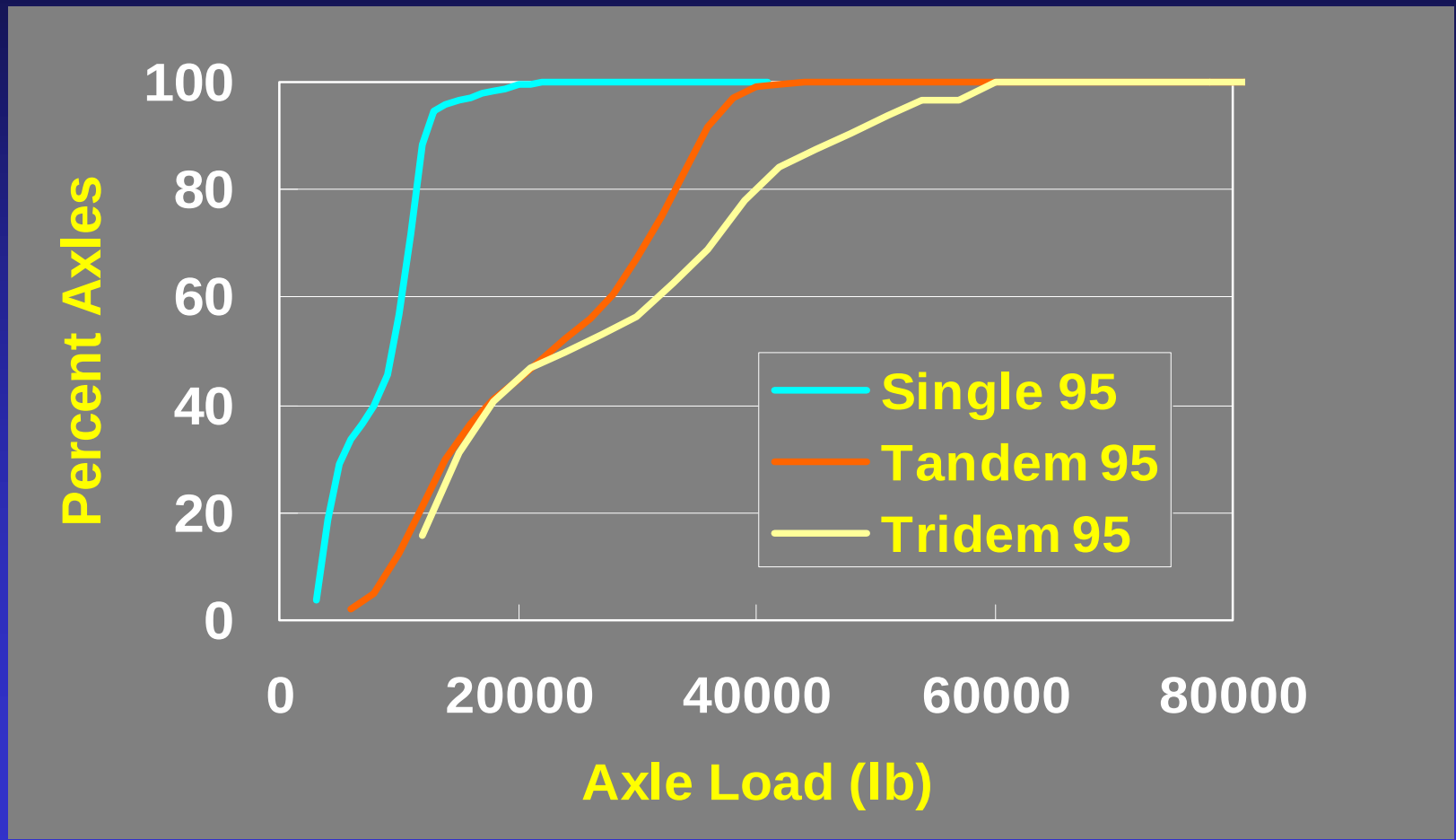
SINGLE AXLE


Percent Axles
40
30
20
10
0
VC 8
VC 9
VC 10
0
15000
30000
45000
Axle Load (lb)

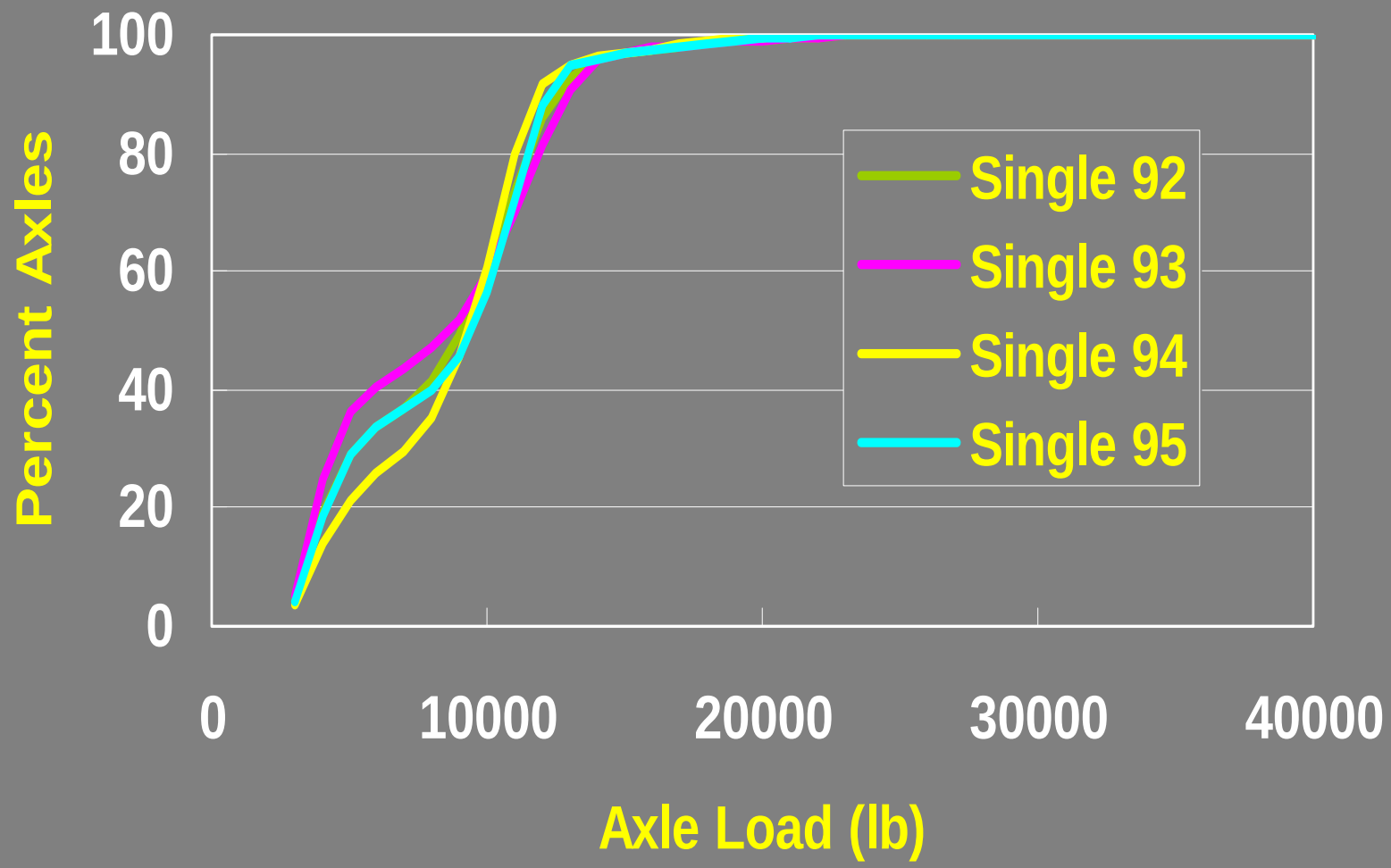
TANDEM AXLE


Percent Axles
20
15
10
5
0
0
30000
60000
90000
Axle Load (lb)
VC 8
VC 9
VC 10

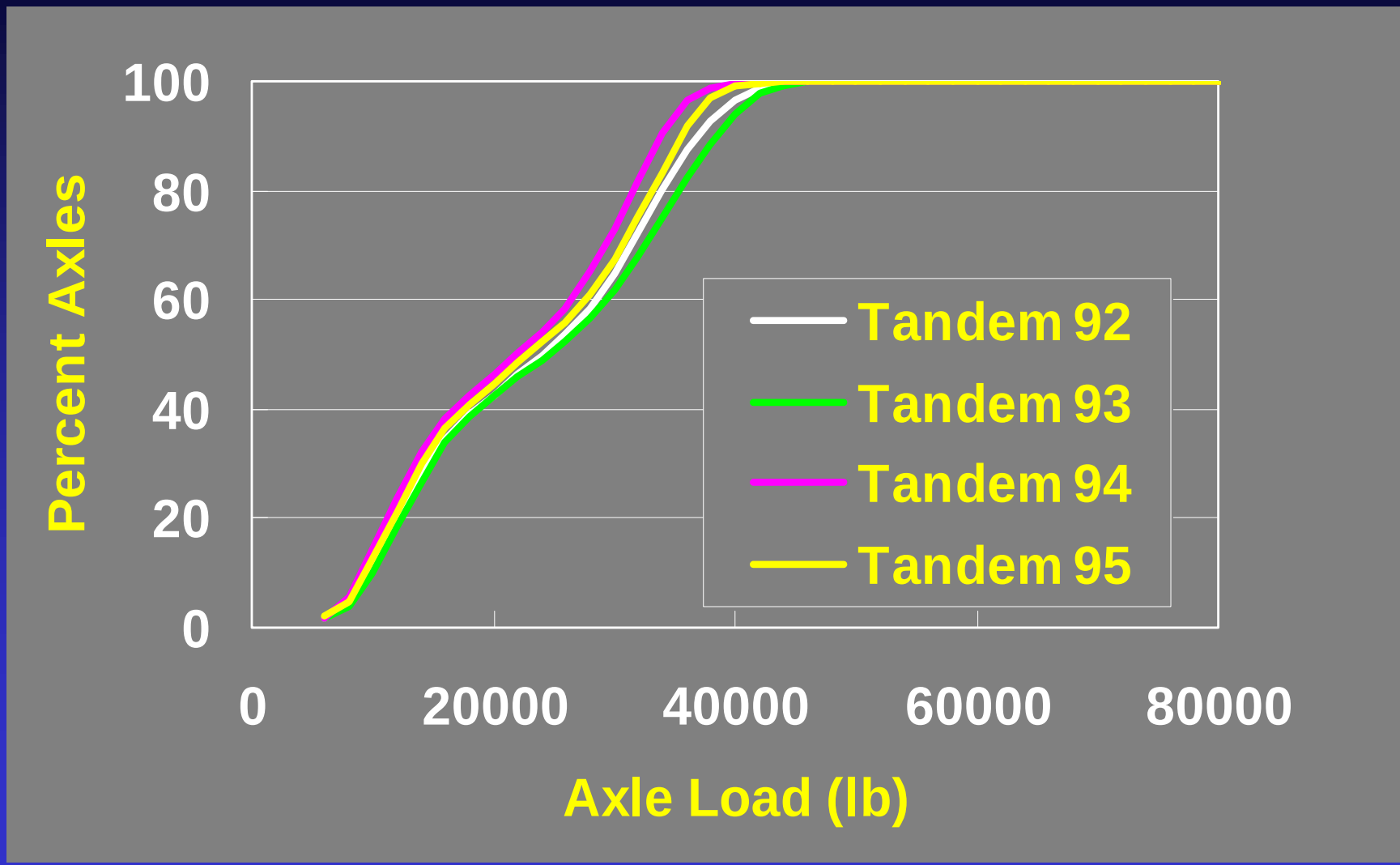
LOAD SPECTRA BY AXLE TYPE



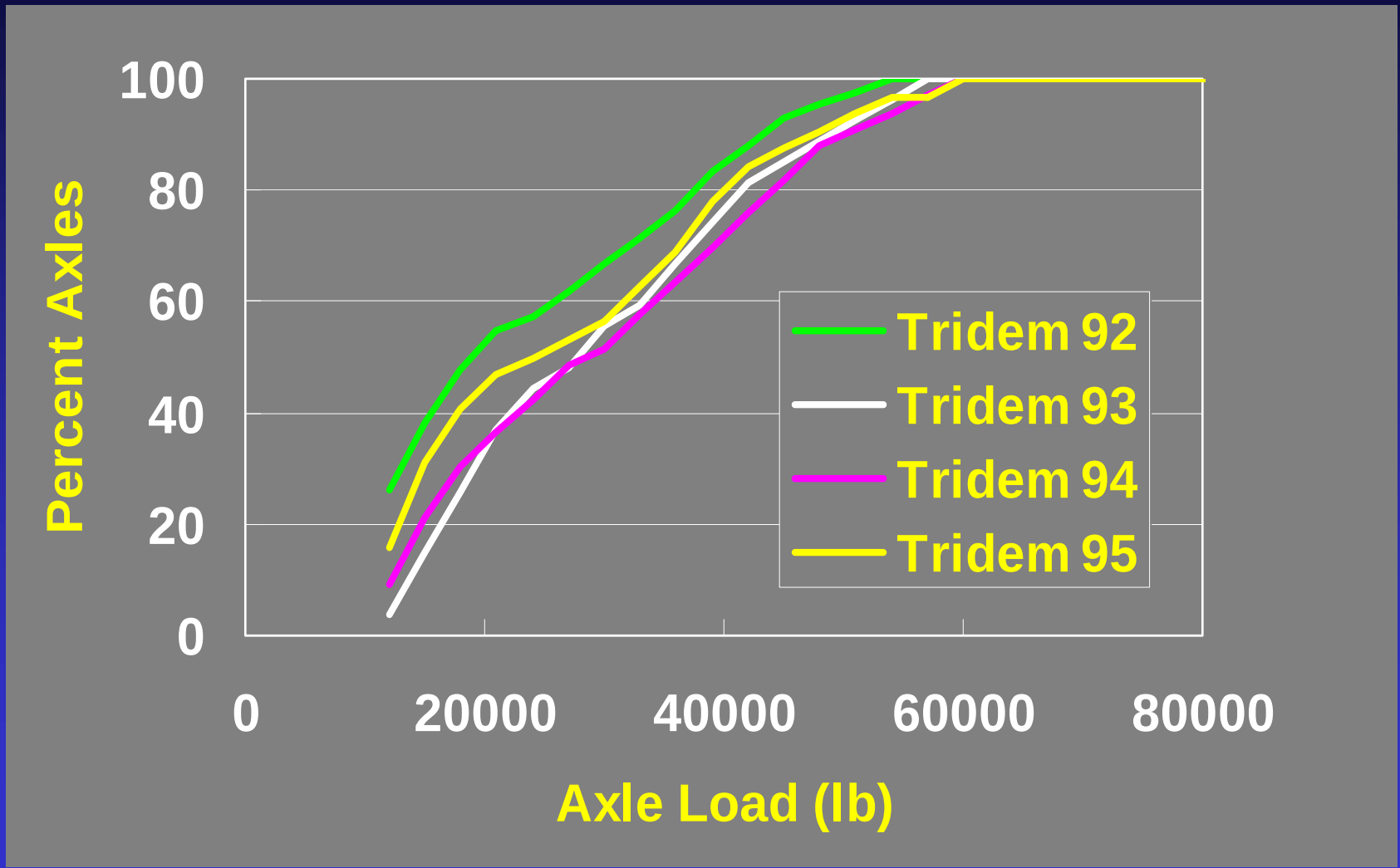
ANNUAL LOAD SPECTRA



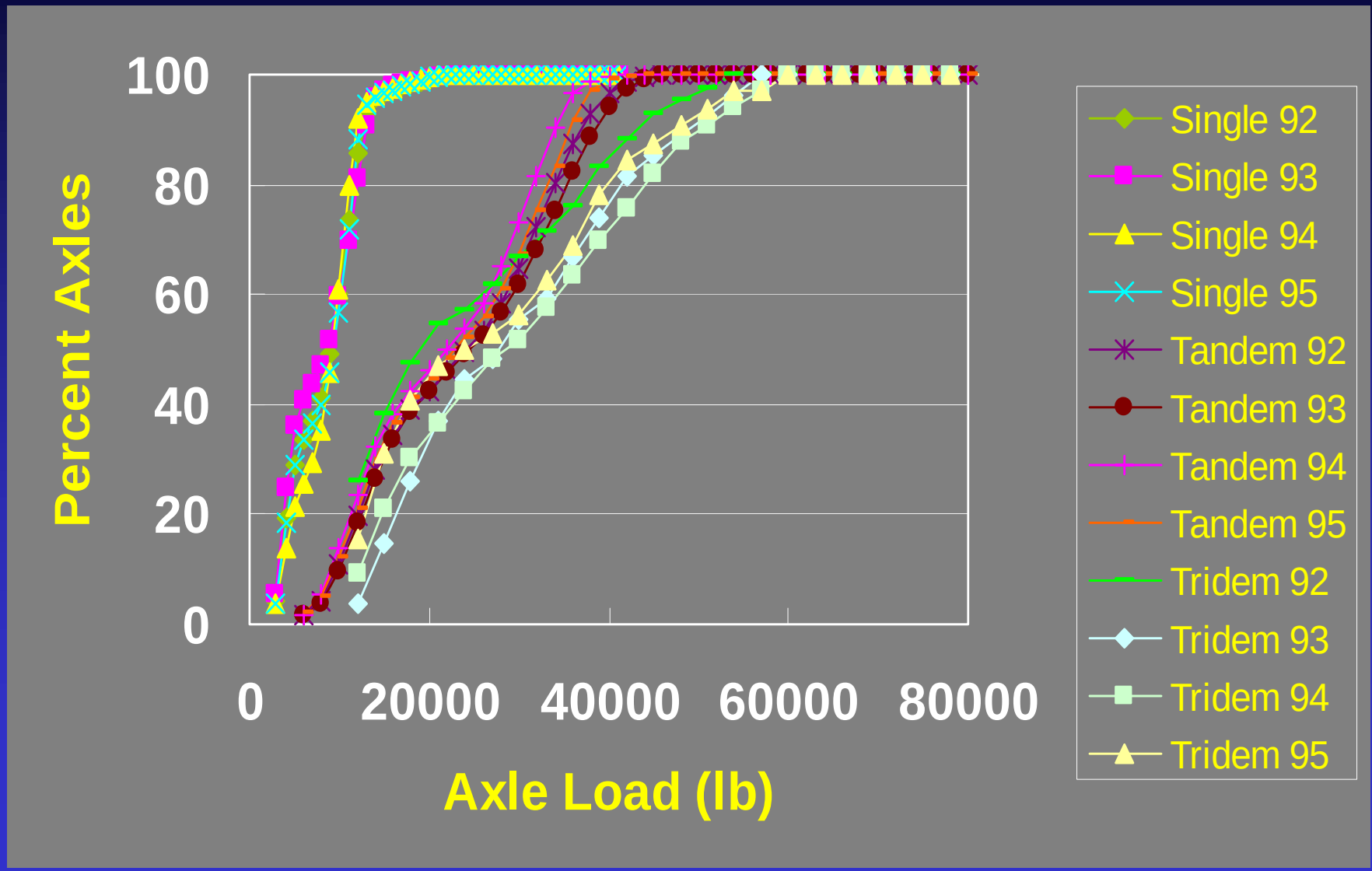
ANNUAL LOAD SPECTRA



ANNUAL LOAD SPECTRA



CUMULATIVE AXLE LOAD



WIM DATA COLLECTION

- Good News
  - Already collected in your state
- Bad News
  - May not analyze/summarize it in the format needed
- NCHRP 1-39 software will help you with this analysis (but will not do it all)

NCHRP 1-39 SOFTWARE

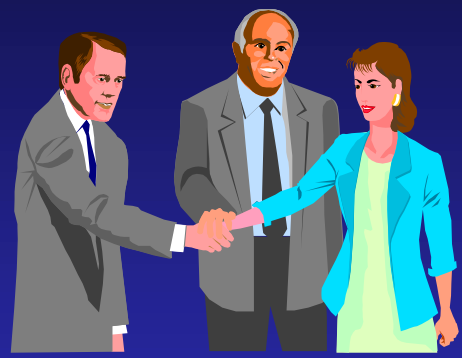
- Take data already collected
- Help organize and summarize it
- Input it into the NCHRP 1-37A software

NCHRP 1-39 SOFTWARE

- Edit-Checked Short-term Site-Specific classification data
- Edit-checked Permanent Class Data
- Quality Checked WIM data
- User defined data groups

WHAT'S NEEDED?

- Resources to:
  - Collect data
  - Quality assure data
  - Analyze data
  - Summarize data
  - Report and make data available



NCHRP 1-39 DESIGN "LEVELS"

	Understanding of Traffic	Classification Data	Weight Data
Level 1	Good	Continuous at Site	Site Specific
Level 2	Modest	Site Specific, but Short	Regional Average
Level 3	Poor	No Actual Class Data	Statewide Average

Work with Traffic Data Collection Folks Early

In order to get the data collected at your locations in time for you to use it…

CONCLUSIONS

- There are various types of WIM equipment
- WIM data is required for M-E design
- WIM data can be successfully collected
- States already collect WIM data
- Additional analyses and formatting may be required

QUESTIONS