Statewide Traffic Data Collection, Processing, Projection and Quality Control

Department of Civil Engineering
The University of New Mexico
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Presentation Outline

- Introduction
- Traffic Data Monitoring at the New Mexico Department of Transportation (NMDOT)
- Problems/Opportunities with Traffic Data Collection in New Mexico
- National State-of-the Practice in Traffic Data Monitoring
- Quality Control and Analysis Procedures for Weigh-in-Motion Data
- Conclusions, Recommendations, Implementation
Introduction

• Research Need:
  • Timely/accurate traffic volume, speed, classification, weight data essential
  • Faulty data leads to faulty decisions regarding planning, design, construction, maintenance, operations
  • Adverse financial consequences associated with erroneous data
  • Process not glamorous; subject to cutbacks in financial support when resources are scarce
Introduction (continued)

- Mechanistic-Empirical Pavement Design Guide (MEPDG) adds new urgency to improve data
  - Procedure relies on reliable data for both current and predicted traffic volume and composition (vehicle weights and types)
  - Under-design of pavement thickness could result in premature pavement failure
  - Over-design of pavement thickness leads to unnecessary present costs of pavement construction
Background

• Volume counting produces factual information relating to annual, daily, hourly, and sub-hourly vehicle counts
• Process involves:
  • Detecting the traffic
  • Recording the count data
  • Storing/presenting the information
• Detection involves tubes, loops, other sensors placed in/near the roadway
• Dramatic improvements in technology in recent years
Traffic Data Monitoring at the NMDOT - Background

- Quality/reliability issues of the late 1980s
- Initial traffic monitoring standards adopted in 1988
  - Standards reviewed/refined every three years
  - Most recent version is for 2011/2013
- New Mexico’s efforts led to national interest in improved standards
  - State survey of DOT practices in Traffic Monitoring
  - Standard practices from FHWA, AASHTO and ASTM
MEPDG Data Needs in NM

- NMDOT pavement design currently based on 1972 AASHTO equation
  - Thickness related to Equivalent Single Axle Loads (ESALs)
  - Necessary to estimate the effects of actual traffic on pavement response and distress
- Mechanistic-Empirical Pavement Design Guide uses actual traffic data (axle load and vehicle classification)
- Design traffic for pavement design is related to the load spectra
Current Data Collection Activities in New Mexico

- **Extent**
  - 68,000 miles of roadway in the state; almost 15,000 miles are monitored by NMDOT or other local/regional agencies
  - Approximately 137 permanent (24/7) count sites
    - About 122 ATRs collect volume, speed, classification
    - 15 AWACs collect weight in addition to the above

- **Equipment**
  - Inductive loops and piezoelectric sensors at ATRs
  - Bending plates and piezoelectric sensors at AWACs
Current Data Collection (continued)

- Short-count (coverage) locations
  - About 15,000 sections identified from CHDB/TIMs databases
  - Counted for 48 hours on a 3- or 6-year cycle, depending on functional classification (about 5,000 per year should be counted)
  - Department employs 90 portable (road tube) counters
  - General office staff, not districts, performs counts
- Developed growth factors applied to counts during off years
Data Collection at Other Bureaus/Agencies

- NMDOT Districts collect some data, primarily for engineering design applications.
- The Mid-Region Council of Governments (MRCOG) supplies count data for the Albuquerque area to the NMDOT.
- The NMDOT ITS Bureau collects camera and sensor data in the Albuquerque area, primarily along the freeway system, for its traffic management operations.
- The New Mexico Department of Public Safety (NMDPS) monitors commercial vehicles at its ports-of-entry and at various temporary locations.
Current WIM Technology in New Mexico

- Bending plates at three locations along US 550
- Piezo sensors at all other locations
- Bending plates perform better but more expensive and difficult to install
- More frequent calibration is key to good performance by piezo sensors
- Influence of temperature is also critical at piezo locations
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Data Reporting

- Monthly/yearly data reporting to FHWA
  - Truck weight studies
  - Volume trends
  - HPMS data
  - LTTP data
- Reports broken down by classification, volume and weight categories
- Growth, axle, daily, seasonal factors along with daily VMT also provided
- Data collected in Districts not typically forwarded to Planning Bureau
Problems/Opportunities with Traffic Data Collection in NM

- Interviews with state traffic professionals
  - Little communication between Districts and General Office regarding traffic data
  - Concerns expressed regarding WIM data
    - Power failures
    - Loss of calibration after a short time
  - Lack of turning movement data
  - ATRs aging/need replacement
    - Need to verify, through manual counts, accuracy of some ATRs
  - Need for data online to enhance timeliness/accessibility
  - Number of counts is sometimes below TMG recommendations
  - Growth rate factor determination sometimes uses an insufficient number of counters
  - Few/no counts done on the local system
Problems/Opportunities with Traffic Data Collection in NM

- Additional written interviews
  - Consultants need (want?) gap data
  - Consultant use of video data collection software
  - Data storage typically in Excel, .pdf, or .csv formats
  - Data typically “sufficient for our needs,” particularly if collected in-house
  - Another mention of WIM sensor calibration issues
  - Some respondents would like to see turning movements to be a “standard inventory requirement.”
Summary of Technical Panel Comments

- **NMDOT responses**
  - Problems revolve around money
    - Not enough staff, equipment, or funds for more frequent calibration
    - Little or no funding for training, database maintenance, or reporting
    - Very few initiatives regarding new technology applications
    - Sense that current number of WIM sites not sufficient to satisfy MEPDG requirements
    - No automated quality control checks applied to WIM data
Summary of Technical Panel Comments

- NM FHWA Response
  - Are all Federal reporting requirements being addressed?
    - Three year counting cycle on the NHS, Principal Arterials, and HPMS sample sections?
    - Vehicle occupancy monitoring?
    - Testing program for field equipment?
  - Operational counters used to determine annual growth rates need enhancement
Successful Strategies in Collection and Analysis (Ref. 26)

- Politics and funding issues
- Personnel, including training
- Incorporating ITS and GPS
- Counts on ramps and bridges
- Motorcycle counts
- Safety at high volume locations
- Frequent replacement of failed piezos
- Non-intrusive detection
- Site calibration issues, especially WIM
National State of the Practice Summary


Common methods used by states for:
count, speed, classification, and weight data

Intrusive vs. non-intrusive technologies

Factors affecting sensor operation

Sensor location and installation issues

WIM technology comparison
### Reported WIM Technology Accuracies

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<th>WIM System</th>
<th>Load Cell/lane</th>
<th>Bending Plate/lane</th>
<th>Kistler Quartz/lane</th>
<th>Piezoelectric Sensor/lane</th>
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<td></td>
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<td>Single Threshold</td>
<td>Double Threshold</td>
<td>Single Threshold</td>
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<td>Accuracy (GVW) (95% confidence interval)</td>
<td>±4-6%</td>
<td>±8-10%</td>
<td>±6-8%</td>
<td>±10%</td>
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<td>Service Life (years)</td>
<td>12</td>
<td>7</td>
<td>7</td>
<td>4</td>
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<tr>
<td>Equipment Cost</td>
<td>$55,239</td>
<td>$21,548</td>
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<td>$17,238</td>
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<td>$1,867</td>
<td>$3,734</td>
<td>$3,304</td>
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<td>Cost per year (over 12 year period)</td>
<td>$8,496</td>
<td>$8,331</td>
<td>$15,738</td>
<td>$11,916</td>
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Quality Control/Analysis Procedures for WIM Data

- Check quality/reliability of NMDOT WIM data
- Visual Basic computer program checks:
  - Time/location of each vehicle
  - Consistency of class, axle, weight information
  - Axle weights and spacings within acceptable ranges?
  - Gross vehicle weight and front axle steering weight frequencies
- Results can be used to conclude if NM WIM data can be used to develop MEPDG traffic inputs for NM
• On US-550 (San Ysidro, Cuba, and Bloomfield) classes 5 and 9 comprise around 80% of the traffic stream. A similar pattern is observed on US-70 (Tularosa).
• On I-40 (Tucumcari) class 9 comprises almost 80% of total traffic.
• These results are logical, and therefore, show consistency of data.
• The Directional Distribution Factor is around 50% showing consistency of data.
• The Lane Distribution Factors are around 45% for the outer lanes and 5% for the inner lanes, showing consistency of data.
• According to the TMG, the GVW frequency distribution for class 9 must present a peak due to unloaded vehicles between 13,500 and 18,000 kg and another peak due to loaded trucks between 31,500 and 37,000 kg.
• According to the TMG, the GVW frequency distribution of class 5 vehicles must have one peak within the range of 2,000 to 6,000 kg.
According to the TMG, the majority of front steering axle weights for class 9 trucks must fall within the range of 3,600 to 5,400 kg.
According to the TMG, for class 5 vehicles most of the front steering axle weights must fall within the range of 1,200 and 2,800 kg.
TRAFFIC INPUTS REQUIRED FOR MEPDG

**Background:** QA/QC procedure for WIM data was previously introduced.

**Objectives:**
- Identify traffic inputs required in MEPDG
- Develop subroutines to obtain MEPDG traffic inputs from WIM data

**Introduction:** MEPDG uses a more complex approach

Hierarchical approach in MEPDG
- Level 1: historical site-specific traffic data
- Level 2: regional or statewide traffic data
- Level 3: default national values/estimates

When WIM data are available for the road of interest, Level 1 pavement design is possible
MEPDG requires a larger number of traffic inputs to characterize the magnitude and frequency of loads:

**Truck Traffic Volume:**
- Two-way AADTT
- Number of lanes
- Percent of Trucks per direction
- Percent of Trucks per lane
- Truck Speed

**Volume Adjustment Factors:**
- Truck Class Distribution
- Monthly Distribution
- Hourly Distribution
- Traffic Growth

**Axle Load Spectra**

**General Traffic Inputs:** Mean Wheel Location, Traffic Wander Standard Deviation, Axle Configuration, Number of Axles by Type and Class, Wheelbase, Tire Dimensions and Inflation Pressures.

Truck Volume Inputs, Volume Distributions, and Axle Load Spectra can be obtained from WIM data. Default values for General Inputs.
• The outputs are:
  o Average Daily Traffic (ADT)
  o Average Daily Truck Traffic (ADTT)
  o Percentage of Trucks
  o Directional Distribution
  o Lane Distribution
  o Vehicle Class Distribution
  o Truck Class Distribution
  o Monthly Distribution by Vehicle Class
  o Vehicle Hourly Distribution
  o Truck Hourly Distribution

• The outputs are tables that can be plotted in Excel.

• As a demonstration, the two subroutines are applied to the classification data collected during 2010 at the Tularosa site (US-70, MP 231.65).
WIM systems collect classification and weight data which are stored in C-files and W-files respectively. These files follow standard format recommended by the TMG.

C-files contain:
- Number of vehicles passing the WIM site per lane and direction during every hour of the day.
- Number of these vehicles by FHWA vehicle class.

Develop 2 subroutines:
1. Imports the C-file into Excel and creates tables to store the results.
2. Processes data and calculates the traffic inputs.
Two-way Daily Traffic Volume

<p>| | |</p>
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<tr>
<td>ADT</td>
<td>6677</td>
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<tr>
<td>ADTT</td>
<td>1021</td>
</tr>
<tr>
<td>Percentage of Trucks</td>
<td>15.30</td>
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Lane Distribution

Directional Distribution

Where:
Positive Direction: East
Negative Direction: West
Outside Lanes: 1 and 4
Inside Lanes: 2 and 3
FHWA classes 5 and 9 are dominant.
Vehicle Monthly Distribution

Percentage of Vehicles (%) vs. Month of the Year

- Month 7 has the highest percentage of vehicles.
- Most months have similar percentage values, indicating a relatively even distribution throughout the year.
• Axle load spectra is a traffic input that can only be obtained from WIM data; it heavily influences pavement performance.

W-files contain

For each truck passing, records a tabulation with the FHWA vehicle class, the number of axles, and the spacing and weight of each axle.

• The axle load spectra can be defined as the percentage of the total axle applications within each load interval for a specific axle type (single, tandem, tridem, and quad) and vehicle class (classes 4 through 13). Its computation is external to MEPDG.

\[
ALDF_{ijk} = \frac{\text{No. of axles for class } i, \text{ month } j, \text{ and load range } k}{\text{Total No. of axles for class } i \text{ and month } j} \times 100
\]
The algorithm is based on the spacing between axles and the weight of each axle. The process has two phases:

1. Classification of axles: A subroutine classifies every axle in single, tandem, tridem or quad. A limit spacing (d) is defined such that:
   • If there are two, three or four consecutive axles separated by a distance smaller than the limit spacing value, then these axles are considered as tandem, tridem, or quad respectively. A single axle is separated from surrounding axles by a distance greater than d.
2. Once all axles are classified by type, the algorithm counts the number of axles whose weight is within the limits of every weight range for every vehicle class and for every axle type. This allows the determination of the axle load distribution factors that compose the axle load spectra.

- The set of subroutines is used to obtain the axle load spectra for New Mexico WIM sites for single, tandem, tridem, and quad axles. The MEPDG default axle load spectra is also included in the following graphs.
Average single axle load spectra compared to MEPDG default:
Average **tandem axle load spectra** compared to MEPDG default:

- Default
- US-70 (Roswell)
- I-10 (Vado)
- I-25 (Lemitar)
- I-40 (Gallup)
- US-550 (Cuba)
- US-62 (Hobbs)
Average **tridem axle load spectra** compared to MEPDG default:
Average quad axle load spectra compared to MEPDG default:
Volume Counts

- Separate volumes into direction per lane
- Adopt AASHTO’s method for calculating AADT from ATR sites
- Utilize idle portable counters:
  - Hire more staff
  - Use consultants
  - Hire students
- Investigate non-intrusive methods of volume collection, especially in high-risk areas
Volume Counts

- Develop a standard protocol for collecting/archiving intersection turning movement counts
  - Video technology
  - Coordinate district activities with central repository
- Selectively use video to verify both permanent and coverage counts
- Develop a procedure for collecting and archiving both occupancy and speed data
Weigh-in-Motion

- Expand the WIM network in the short term as follows:
  - Existing 15 sites refurbished
  - 21 new sites constructed
- Load cell technology should be installed at new sites, if funding exists
  - Lower cost bending plates and kistler lineas quartz are also good options
  - Piezoelectric sensor locations should be replaced as they become obsolete
- Calibration must be performed at least once a year
Weigh-in-Motion

- WIM data should be retrieved daily via telemetry
- Development of a reader for vendor output files will allow TRADAS to process WIM data
- The developed subroutines should be applied to reliable WIM data
- PrepME can be used for WIM quality control and MEPDG traffic input subject to the resolution of compatibility issues
- NMDOT/NMDPS interaction/cooperation should be investigated
A reporting module should be developed with traffic data provided in both Excel and .pdf format. It should contain, at a minimum, the following:

- Overall and truck AADT – total volumes and by vehicle classification
- Traffic trend reports – hourly, daily, monthly and seasonal variations at individual sites
- Annual highway mileage and vehicle classification by functional class
- Vehicle miles of travel
- Expansion and growth factors
Web-Based Data Management System

• A GIS-based module allowing display of counts by day of week, time of day and by location, county, route and functional class
  • Non-traffic information could also be included
    • Weigh stations
    • Park-and-ride lots
    • Etc.
  • Links should be color-coded based on traffic volume
Staffing, Training

- The current staffing level should be expanded as follows:
  - 3 field personnel for the count program
  - 2 office personnel for data processing
  - 3 WIM technicians
  - 1 traffic professional and 1 database administrator (long term)
- If contractor help is necessary, it should be devoted to conducting coverage counts
- Training should involve attendance at national conferences such as NATMEC and meetings of the Chaparral User Group, attending the NHI training course on the Traffic Monitoring Guide, and an in-house certification program
Implementation

- Increased funding is necessary as follows:
  - Short-term (next five years)
    - $430,000/year (personnel)
    - $5,000,000 (equipment)
  - Long-term (beyond five years)
    - Additional $150,000/year (personnel)
    - Minimum of $5,000,000 (equipment)
  - Appropriate department personnel involved in the traffic monitoring program must approach senior management with a plan for the program including a timeline and anticipated costs of implementation.