Results of ADOT's Survey: Successful Weigh-In-Motion Practices with Focus on Piezo-Electric Systems

Sponsored by
Arizona Department
of Transportation

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ADOT

OUTLINE

- Study Background
- Summary of Survey Results
- Critical Elements of Successful WIM Operation

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BACKGROUND

- ADOT plans to install 30+ WIM stations to support:
  - Pavement design
  - Weight enforcement
  - Freight travel demand modeling

- WIM technologies of interest:
  - Piezoelectric quartz sensors (Kistler)
  - Piezoelectric polymer sensors (PVDF "Brass Linguini" [BL])

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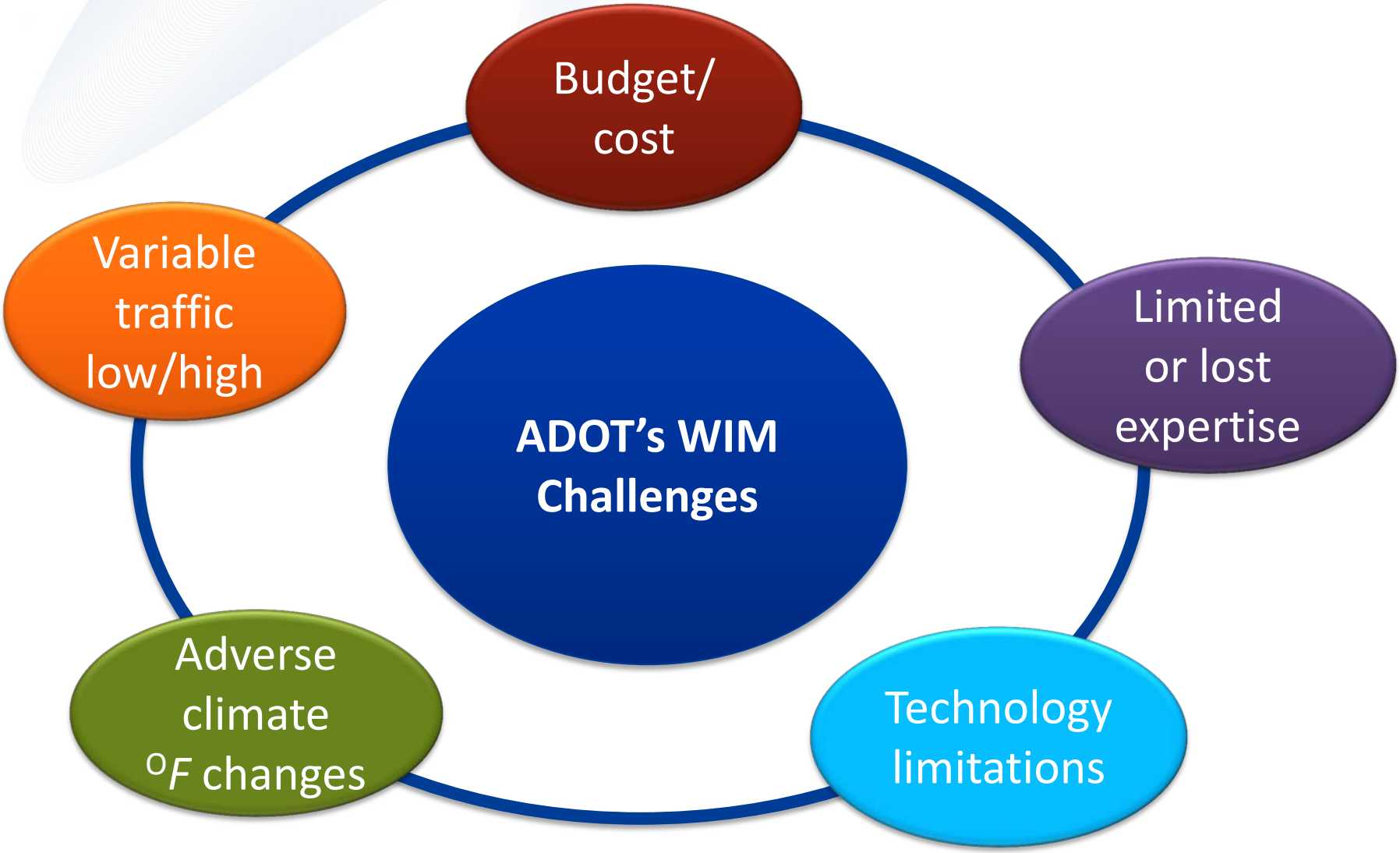
BACKGROUND (CONT.)



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PROJECT OBJECTIVE

- Review other agencies' successful WIM practices
  - Literature search + survey
  - Focus on
    - Practices for achieving WIM data quality
    - Conditions and constraints similar similar to ADOT's
    - Piezoelectric WIM systems
- Seek inputs from industry leaders and national experts in WIM area
  - TRB, NATMEC, and ISWIM
- Develop a WIM Guidebook
  - Installation, calibration, maintenance, data quality assurance, and personnel

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SUMMARY OF SURVEY RESULTS

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SURVEY PARTICIPANTS

State DOTs:

Connecticut	Transportation Engineer
Florida	Administrator, Transportation Data
Georgia	State Transportation Data Administrator
Louisiana	Director, Louisiana Transportation Research Center
New Mexico	Chief, Data Management Bureau
Pennsylvania	Manager, Transportation Planning Division
Texas	Traffic Data Systems Engineer
Virginia	Program Manager, Traffic Engineering Division

US DOT, FHWA:

OHPI	Senior Transportation Specialist
OIR&D LTPP	Highway Research Engineer

Experts:

International Society for Weigh-in-Motion
TRB Subcommittee on Weigh-in-Motion
TRB Highway Traffic Monitoring Committee
TRB LTPP Traffic ETG members
Vendor/WIM services provider (multiple sensors)
Consultant/Academia

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TOPICS COVERED IN WIM SURVEY

- Equipment used by other agencies
- Maintenance and calibration practices
- Data accuracy and quality assurance practices
- Data sharing between state transportation and weight enforcement agencies
- Operation support and personnel qualifications

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SUMMARY OF SURVEY RESULTS: WIM Equipment

- Current WIM installations (all participants combined)
  - 308 WIM sites
  - 4 sensor types (most to least common):
    - Piezo-polymer, piezo-quartz, bending plate, load cell
  - 8 controller types (alphabetical order):
    - IRD-ISINC, IRD TC540, ECM, Mettler-Toledo, PAT Traffic, Peek ADR, Raktel, Telemetrics
  - All sites with piezo-polymer sensors use temperature compensation
    - Most agencies use auto-calibration; one uses temperature probes

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SUMMARY OF SURVEY RESULTS: WIM Equipment

- Future WIM installations (participating agencies):
  - Move away from piezo-polymer sensors for weight
  - Continue to use piezo-polymer sensors for vehicle classification
  - Use piezo-quartz sensors (AC or PCC pavements) or bending plates (PCC pavements) for weight measurement

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SUMMARY OF SURVEY RESULTS: WIM Site Selection/Qualification

Criteria	very important	moderately important	not important
Traffic conditions (free-flow, no X, no signals)	**10**		
Easy and safe access for technicians	**10**		
Pavement condition other than smoothness	**10**		
Pavement smoothness	**9**	**1**	
Roadway geometrics	**9**	**1**	
Roadway gradient	**7**	**3**	
Cellular service coverage	6	4	
Upgrade of existing traffic monitoring site	5	1	4
Proximity to test truck turnarounds	1	8	1
Proximity to AC power service		4	6
Proximity to landline telephone		4	6

bold font = most important

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SUMMARY OF SURVEY RESULTS: WIM Installation

- Installation procedure/specification:
  - Contract specification
  - Manufacturer's installation manuals
- Personnel
  - Certified installers (manufacturers' certification)
  - Installation QA inspector independent of contractor
- Initial WIM calibration
  - By certified installer or manufacturer's representative
- Proper documentation and acceptance testing

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SUMMARY OF SURVEY RESULTS: WIM Maintenance

- Documentation/procedure:
  - Contract specification
  - Manufacturer's user's guide
- Frequency of preventive maintenance:
  - Annually
  - Semi-annually
  - As needed

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SUMMARY OF SURVEY RESULTS: WIM Calibration

- Documentation/procedure:
  - ASTM E1318-09
  - Contract or agency procedure
  - Manufacturer's user's guide
- Frequency of calibration:
  - Depends on sensor type, funding, and staff availability
  - Piezo-polymer:
    - Annually, as-needed, auto-calibration, only initial install
  - Piezo-quartz:
    - Annually, or 18 months or less

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SUMMARY OF SURVEY RESULTS: WIM Calibration

- Calibration truck:
  - Loaded class 9 truck
  - 1 or 2 trucks
- Number of test truck runs:
  - 4 to 40, depending on agency

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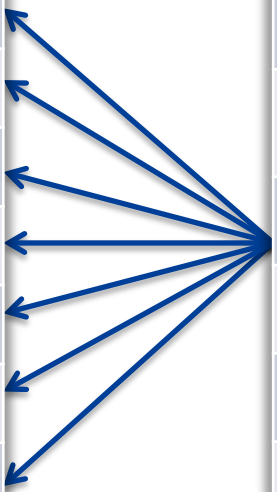
SUMMARY OF SURVEY RESULTS: WIM Data Customers and Data Types

Customers (from most to least common)
• Planning
• Research
• Design
• Asset Management
• Safety
• Weight Enforcement
• Environmental



Data Collected by WIM
• Gross Vehicle Weight
• Axle Weight
• Vehicle Classification
• Traffic and Truck Volume
• Speed
• Per-Vehicle Records

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SUMMARY OF SURVEY RESULTS: WIM Data Accuracy by Customer

Discipline	Bias (Mean % error)	Tolerance (+/-% error)
Weight Enforcement	<2 to 5%	<2 to 10%
Planning	2 to 10%	2 to 10%
Safety	2 to 10%	2 to 10%
Research	<2 to 20%	2 to 20%
Design	2 to 20%	2 to 20%
Asset Management	2 to 20%	2 to 20%
Environmental	2 to 20%	2 to 20%

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SUMMARY OF SURVEY RESULTS: WIM Data QC Checks

General Checks
Data file size
Polling error statistics by type of error
Site identification and time parameters

Vehicle Volume and Class Checks
Hourly or daily total volume
Hourly or daily volume by class
Hourly or daily volume of class 9
0 counts or over 2,500 per hour, lane
Axle spacing: min/max/historical
Total wheelbase by vehicle class

Weight Checks
Average GVW of class 9 vehicles per day
Average front axle weight of class 9
Class 9 loaded/unloaded peak loads
Seasonal shift in class 9 weight distribution
Overweight vehicles
Left and right axle weight
Percent class 9 vehicles with weight warnings

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SUMMARY OF SURVEY RESULTS: Staffing

- WIM Program Manager
- Field Technician(s)
- Data Analyst
- Contracted Staff or Operation

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SUMMARY OF SURVEY RESULTS: Staffing

WIM Program Support

WIM Program Support Staff	Number of Agencies
In-house staff, full-time employees	1
In-house support and on-site contract staff	2
Part or all of WIM operation is outsourced	7

Outsourced WIM Operations

WIM Operation	Number of Agencies
Installation	7
Maintenance	6
Calibration	5
Field operations QA	4

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CRITICAL ELEMENTS OF SUCCESSFUL WIM OPERATION

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CRITICAL ELEMENTS OF SUCCESSFUL WIM OPERATION (CONT.)

- WIM technology (considering piezo sensors only)
  - Quartz-piezo sensors for sites requiring high-quality WIM data (ASTM E1318-09 Type I data)
  - Piezo-polymer sensors used in combination with auto-calibration feature to collect ASTM E1318-09 Type II data
    - May be challenging on low truck volume roads
    - May require more frequent calibration than quartz sensors
  - WIM controller that supports:
    - Temperature compensation
    - Speed-related compensation factors
    - Independent GVW and front axle correction factors

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CRITICAL ELEMENTS OF SUCCESSFUL WIM OPERATION (CONT.)

- WIM site location
  - Location selected by the user may not be conducive to accurate weight measurements
  - Potential WIM site locations must be evaluated prior to installation using ASTM E1318-09 criteria
  - Document WIM site evaluation findings and conclusions using WIM Site Evaluation Report or Form

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CRITICAL ELEMENTS OF SUCCESSFUL WIM OPERATION (CONT.)

- WIM installation
  - In accordance with the manufacturer's specifications
  - Certified installers
  - Quality Assurance inspector (not affiliated with installers)
  - Initial calibration:
    - Trucks, temperature, speeds
  - Proper documentation/reporting:
    - WIM Installation Audit Form
    - Non-Compliance Report
    - As-built plan, photographs
    - Results of initial calibration

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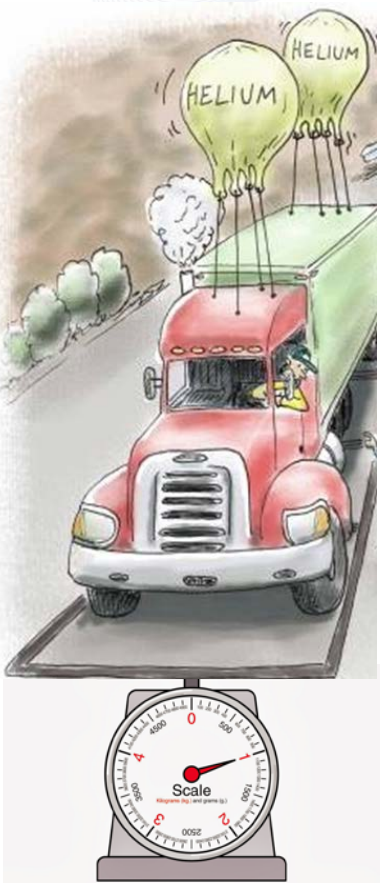
CRITICAL ELEMENTS OF SUCCESSFUL WIM OPERATION (CONT.)



- WIM calibration
  - Implement schedule for regular calibration
  - Calibration frequency is a function of:
    - Sensor type
    - Site performance history
    - Performance requirements (WIM data accuracy requirements from the user)
  - Calibration vehicle (test truck)
    - Common heavy truck type and speed
  - Pre-visit data analysis (before field calibration)
    - Truck classification, speed, class 9 GVW, front axle weight, tandem axle spacing

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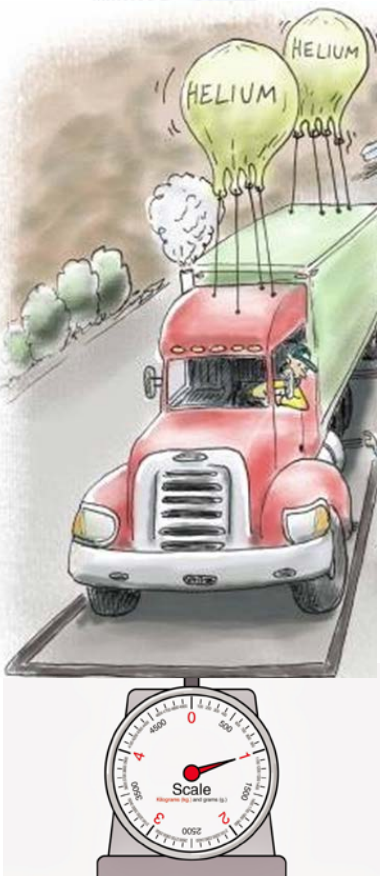
CRITICAL ELEMENTS OF SUCCESSFUL WIM OPERATION (CONT.)



- WIM calibration
  - Site and equipment assessment
    - Visually inspect WIM system components, verify equipment operation, evaluate truck-pavement interaction
  - Calibration procedure
    - Conduct sufficient number of pre-calibration test truck runs (10 to 30)
    - Adjust system factors to minimize mean error (bias) – focus on GVW accuracy
    - Conduct 2nd set of test truck runs after adjustments (10 to 30)
    - Evaluate results against performance requirements
  - Post-visit data analysis (2-4 weeks after calibration)
    - Develop comparison data set, evaluate data before and after calibration, report calibration results

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CRITICAL ELEMENTS OF SUCCESSFUL WIM OPERATION (CONT.)

- Comprehensive maintenance program
  - Preventive maintenance
    - Schedule annually or semiannually
    - Follow established procedure
  - Unscheduled maintenance
    - Importance of timeliness, system downtime
  - Troubleshooting and repair
    - Procedure, logical progression
    - Service-ready spares
  - Reports and record-keeping
    - Maintenance records, trends, high-failure items

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CRITICAL ELEMENTS OF SUCCESSFUL WIM OPERATION (CONT.)

- Routine monitoring of WIM system performance
  - ➢ Automated daily or weekly checks of downloaded data files
  - ➢ Develop comparison data set (CDS)
    - Use WIM data 2 to 4 weeks immediately after calibration
    - Compute truck weight summary statistics
  - ➢ Regularly (weekly, bi-weekly, or monthly) check downloaded WIM data against CDS values:
    - ✓ Truck distribution analysis
    - ✓ GVW analysis
    - ✓ Class 9 front axle weight analysis
    - ✓ Class 9 tractor tandem spacing analysis
  - ➢ If any of the elements are out of typical range, notify the WIM program manager

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CRITICAL ELEMENTS OF SUCCESSFUL WIM OPERATION (CONT.)

- Staffing needs (depend on the size of WIM operation)
  - Dedicated to the WIM program, outsourced, or shared with other agency programs

- WIM program manager
  - Overall program management, liaison with data users
  - Supervise WIM personnel
- WIM QA inspector/WIM specialist
  - Oversee and manage WIM system installations, maintenance, and calibration
- WIM field technician
  - Maintain, calibrate, and repair WIM systems
  - Provide on-site QA of WIM installations and repairs
- WIM data analyst/office technician
  - Download, process, and QC WIM data
  - Summarize data for reporting

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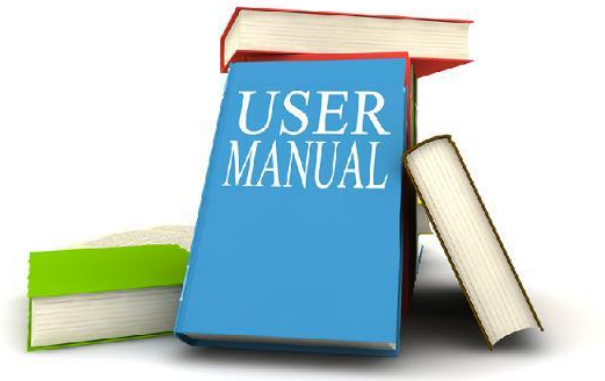
CRITICAL ELEMENTS OF SUCCESSFUL WIM OPERATION (CONT.)

- Implement and maintain consistent reporting procedures and operational manuals for critical WIM functions
  - Preserve in-house knowledge
  - Provide consistency and continuity of operations
  - Provide smooth staff rotations/transitions
- Include manuals and report/form templates for
  - Site selection and evaluation
  - Site installation quality assurance
  - Site calibration
  - Site maintenance and troubleshooting
  - Data quality assurance



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Questions?

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