ICWIM6 & NATMEC 2012

CONCLUSIONS ON WIM

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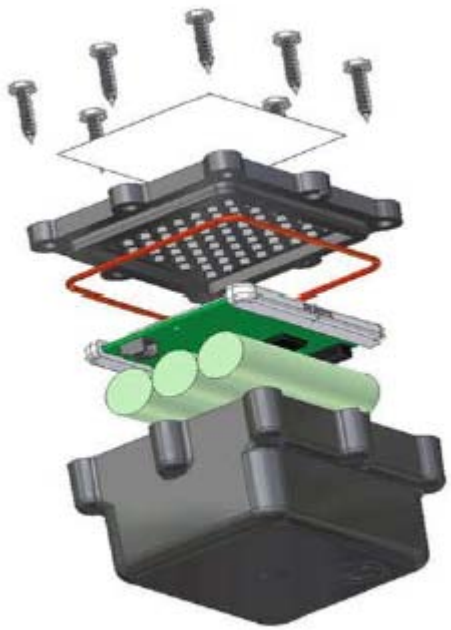
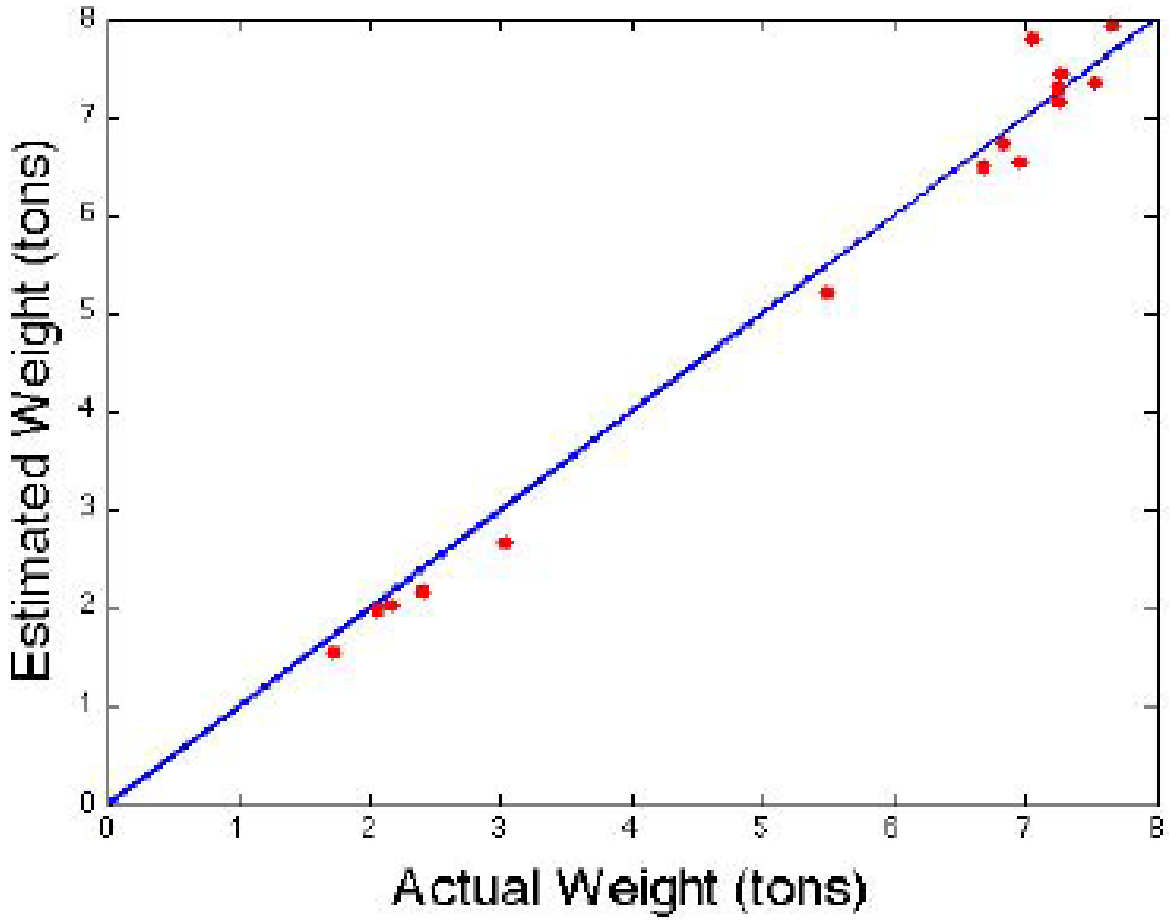
New WIM Sensor



<u>Varaiya (USA):</u>

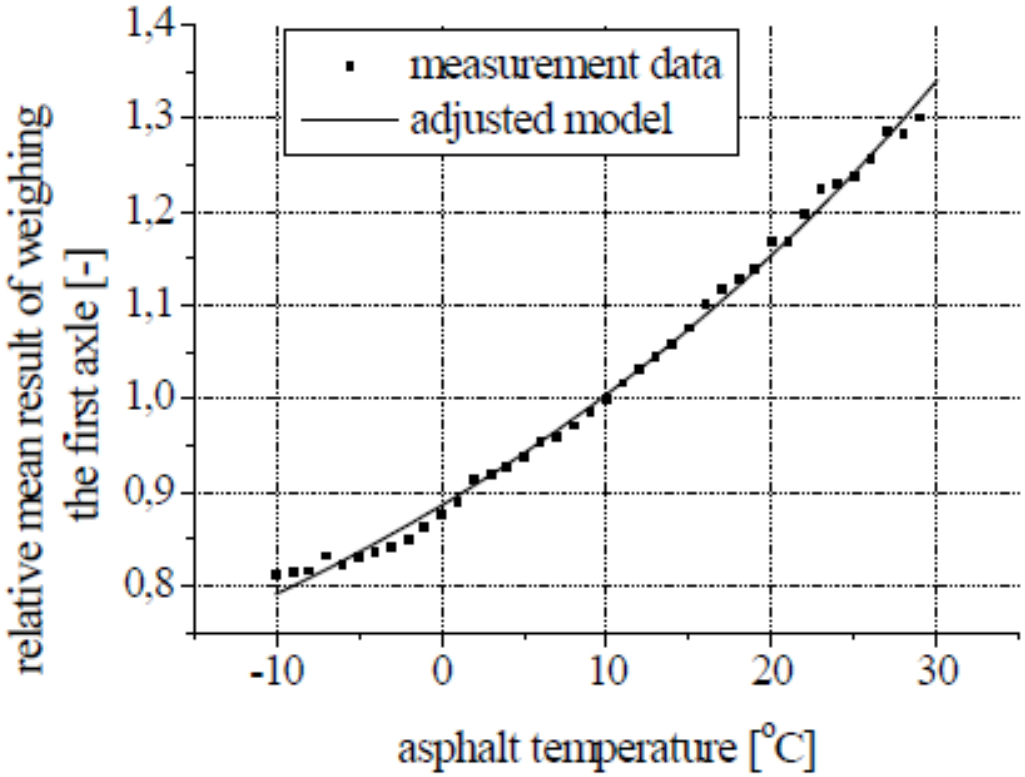
- **Accelerometer technology**
- **Based on pavement vibration**

New WIM Sensor



- **Seems to have potential!**

Auto- calibration



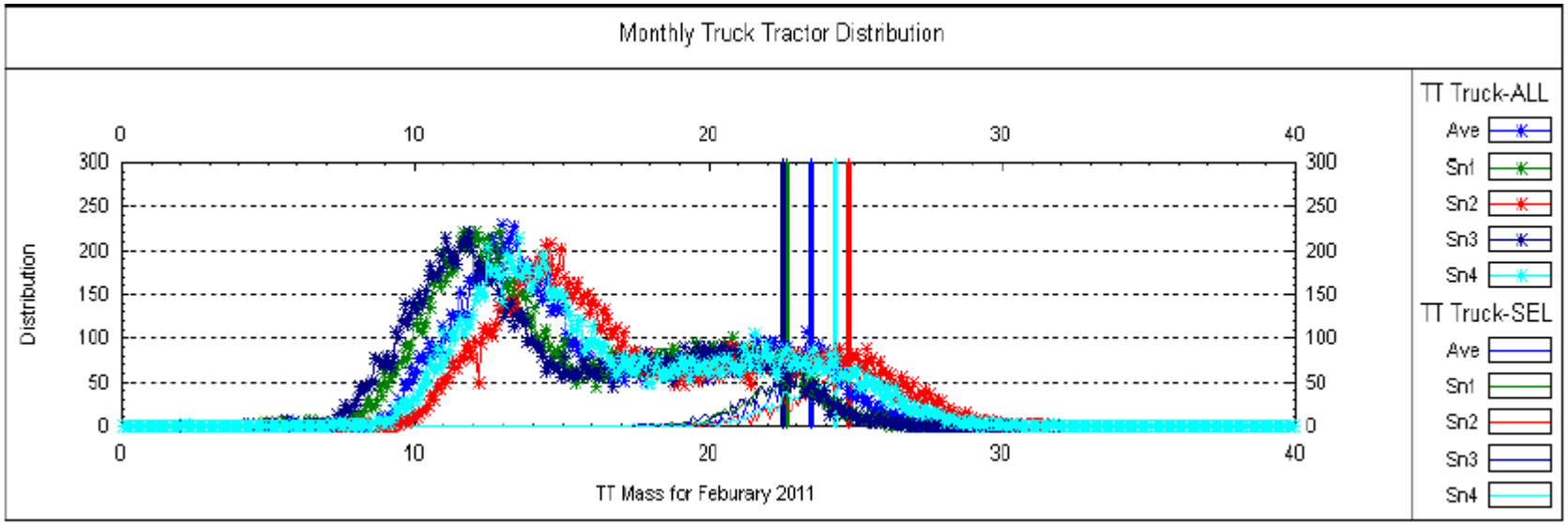
- **<u>Burnos (Poland)</u>: Strong temperature sensitivity (piezo- polymer) – 50% diff in mean weight**

Auto- calibration

- Autocalibration presented by Mark Hallenbeck and Daniel Stancyzk in ICWIM1
- Steer axle weight in 5- axle semi- trailer has a standard deviation of 7.3% of mean
- System recalibrated every time an eligible truck passes
- 300 updates of calibration factor per day!

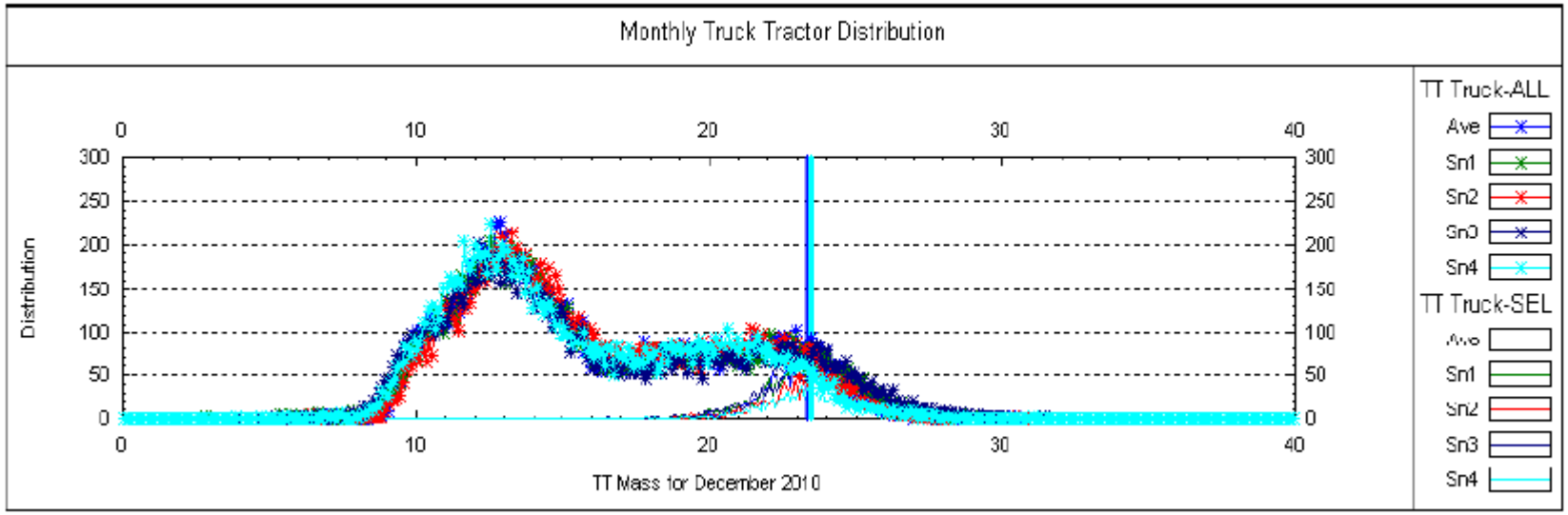
Auto- calibration

- <u>Sik (South Africa):</u> Monitoring monthly statistics
- Or running count of 600 trucks
- Sets mean tractor weight to 21.8 t

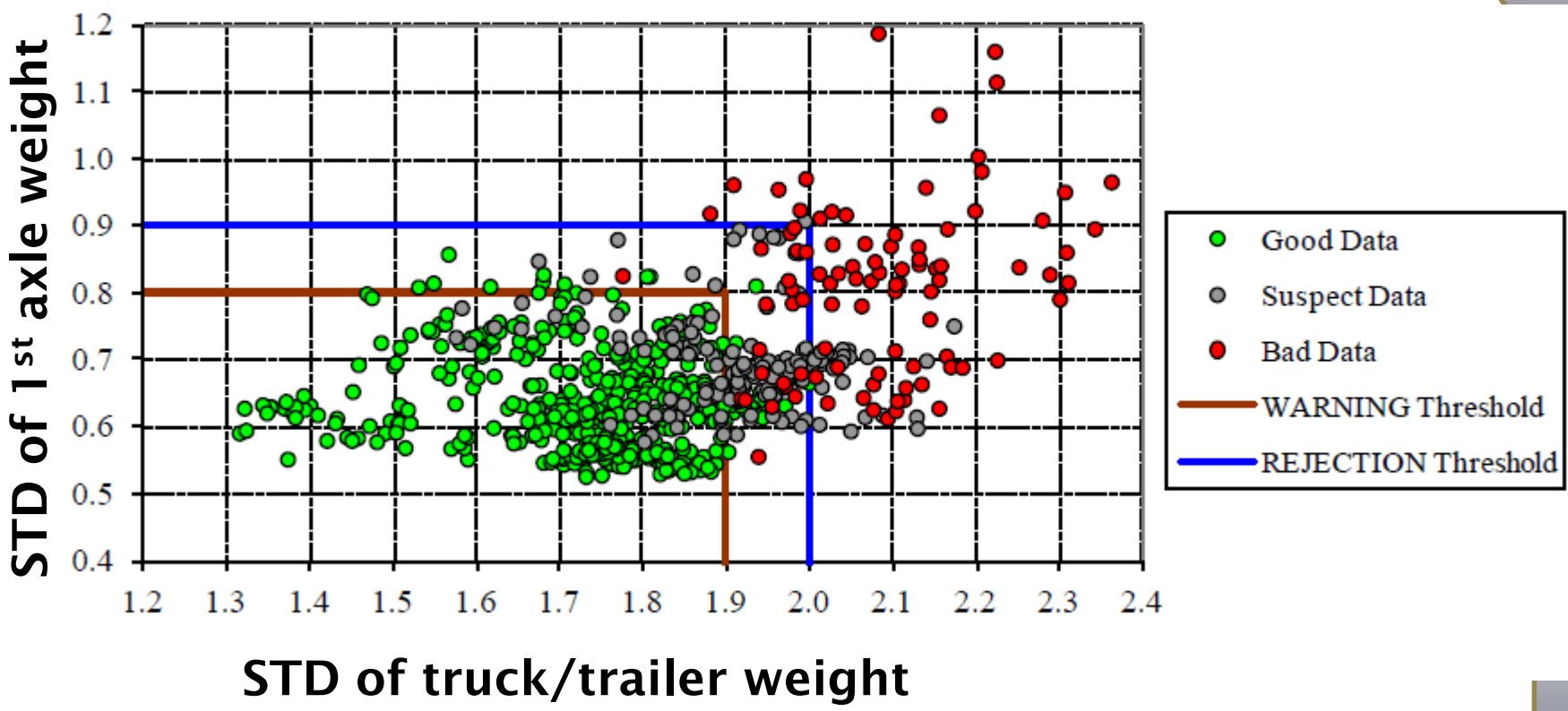


Auto- calibration

- **After updating**



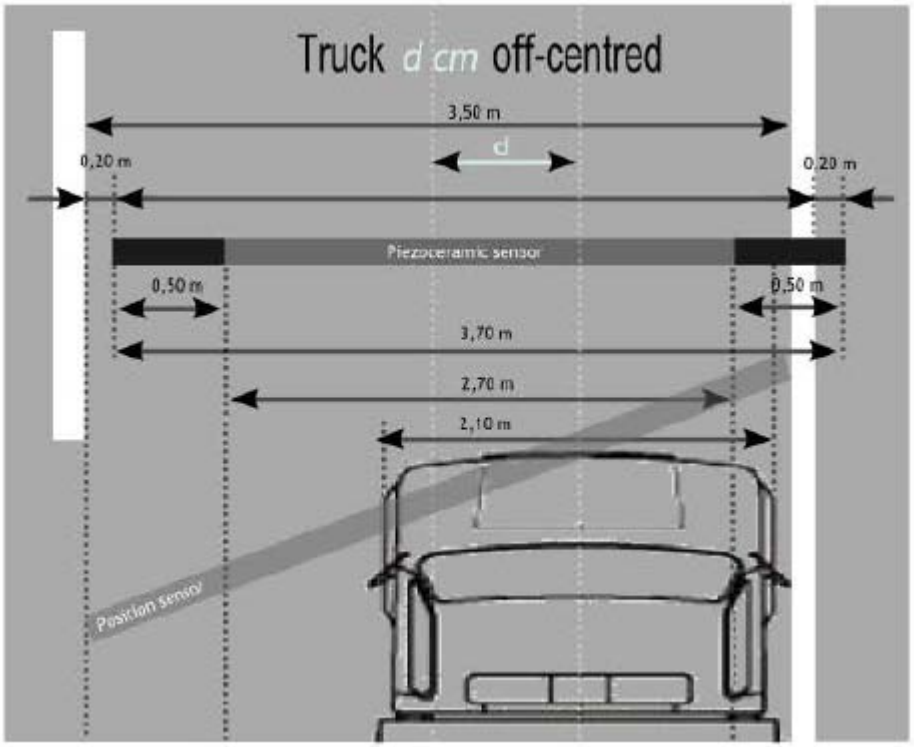
Auto- calibration



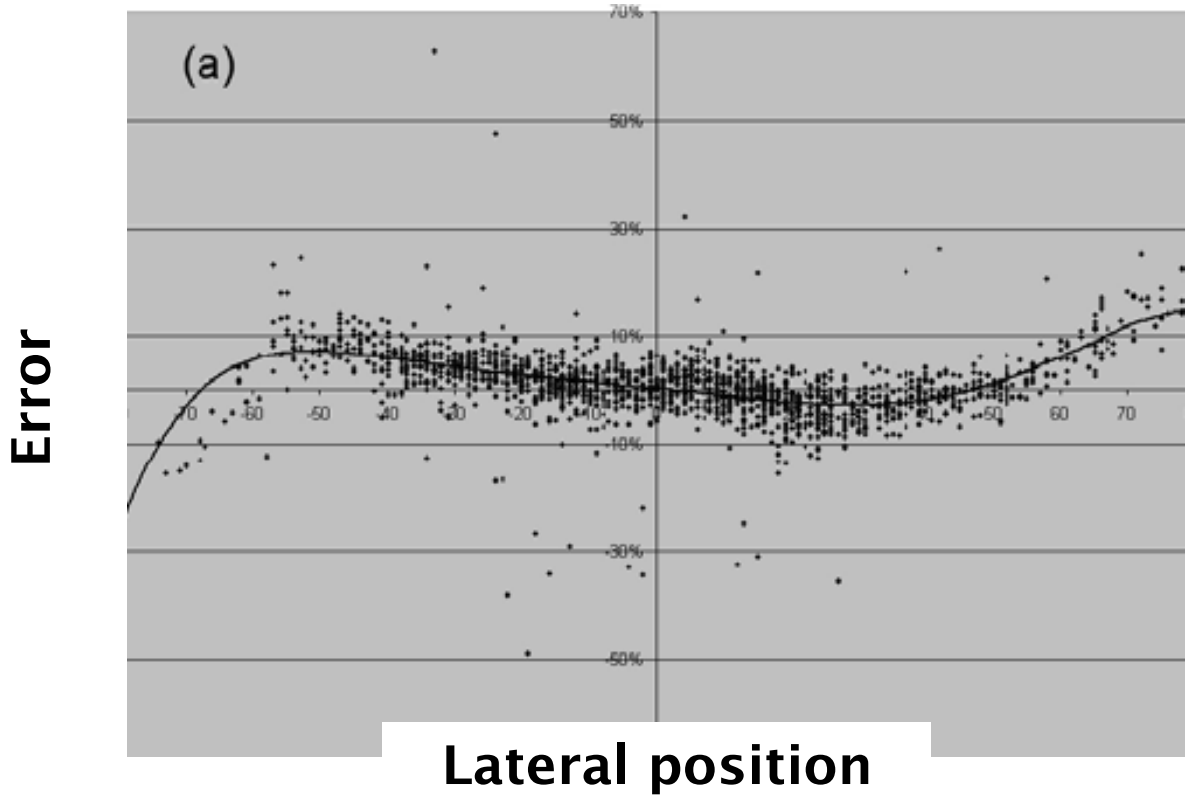
- **<u>DeWet:</u> Warning threshold & reject threshold**

Vehicle Wandering

- **First raised by Labry (France) at a previous ICWIM**
- **<u>Klein (France):</u> WIM sensors less accurate when vehicle is near the edge**



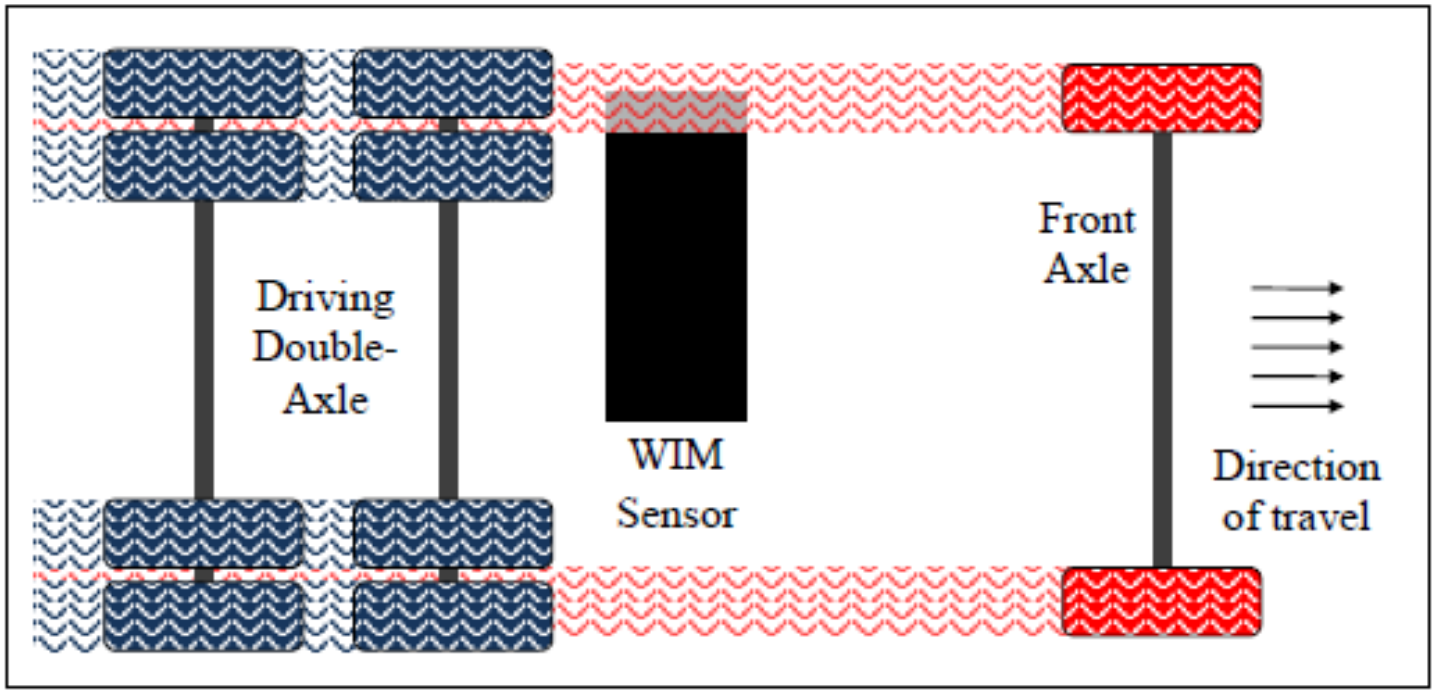
Vehicle Wandering



- **Remove suspect data from auto- calibration database**

Vehicle Wandering

- <u>DeWet</u> – Sensor 'clipping':
- Uses auto- calibration to identify suspect data



Vehicle Wandering

Doupal (Czech Republic):

- **Sensors to monitor lateral position and assess validity of measurements**

Vehicle Wandering

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- **Sensors to monitor lateral position and assess validity of measurements**

Papagiannakis: Use longer sensors!

Bridge WIM Algorithms

1st Level: Moses's Conventional Approach

- Fast, efficient, reliable

Bridge WIM Algorithms

2nd Level Bridge WIM Algorithm

- **More intensive calculations**
- **But more accurate**

Bridge WIM Algorithms

3rd Level (Next Generation) Bridge WIM Algorithm

- Very complex calculations
- Very accurate

Bridge WIM Algorithms

1st Level System (Yamaguchi):

- Integrating area under response curve – simple, easy to use, relatively low accuracy

1st Level System (Schmidt):

- Local testing of conventional Bridge WIM

Axle Detection (Taylor):

- New ways to detect axles with nothing on the road

Bridge WIM Algorithms

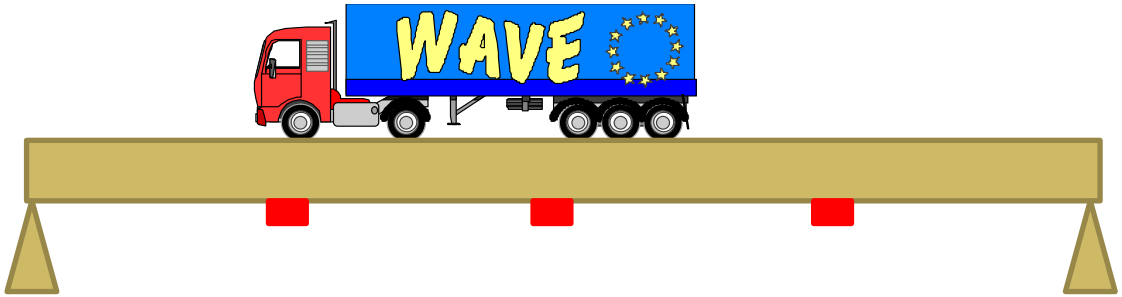
2nd Level System (Znidaric):

- **'Strip Method' to deal with multiple presence (multiple trucks on bridge simultaneously)**

Bridge WIM Algorithms

2nd Level System (OBrien):

- Uses sensors at multiple longitudinal locations
- Calculates axle weights at many points in time (and averages the results)
- Uses 'regularization' to address ill- conditioning of equations



Bridge WIM Algorithms

3rd Level System (Uddin):

- **Uses dynamic equations (rather than static) to relate measurements to axle weights**
- **Anticipating step change improvement in accuracy**

Pre- selection & Enforcement

Leal (Spain) re Chile:

- Successful programme of pre- selection and enforcement
- Load cells with high accuracy
- 25 mobile units
- Overload now about 1%

Pre- selection & Enforcement

Wrobel (Poland):

- **Make and Model Recognition by Image Analysis**
- **Enforcement by Make and Model**

type: truck
manuf: iveco
color: gray

- **60 000 model variants**

type: car
manuf: peugeot
color: dark red

Pre- selection & Enforcement

Doupal (Czech Rep):

- Probably will be 1st country in world to do direct enforcement of overload using WIM
- President will sign new law in August
- Implementation of new regulations in Fall

- Class A(5) systems tested
- Vibration monitoring (measure of pavement stiffness)
- Vehicle wandering monitoring
- Validity checking – 30% to 35% rejection

Standardization

- <u>Jacob (France):</u> European Draft Standard
- Based on COST323 standard
- Very complex

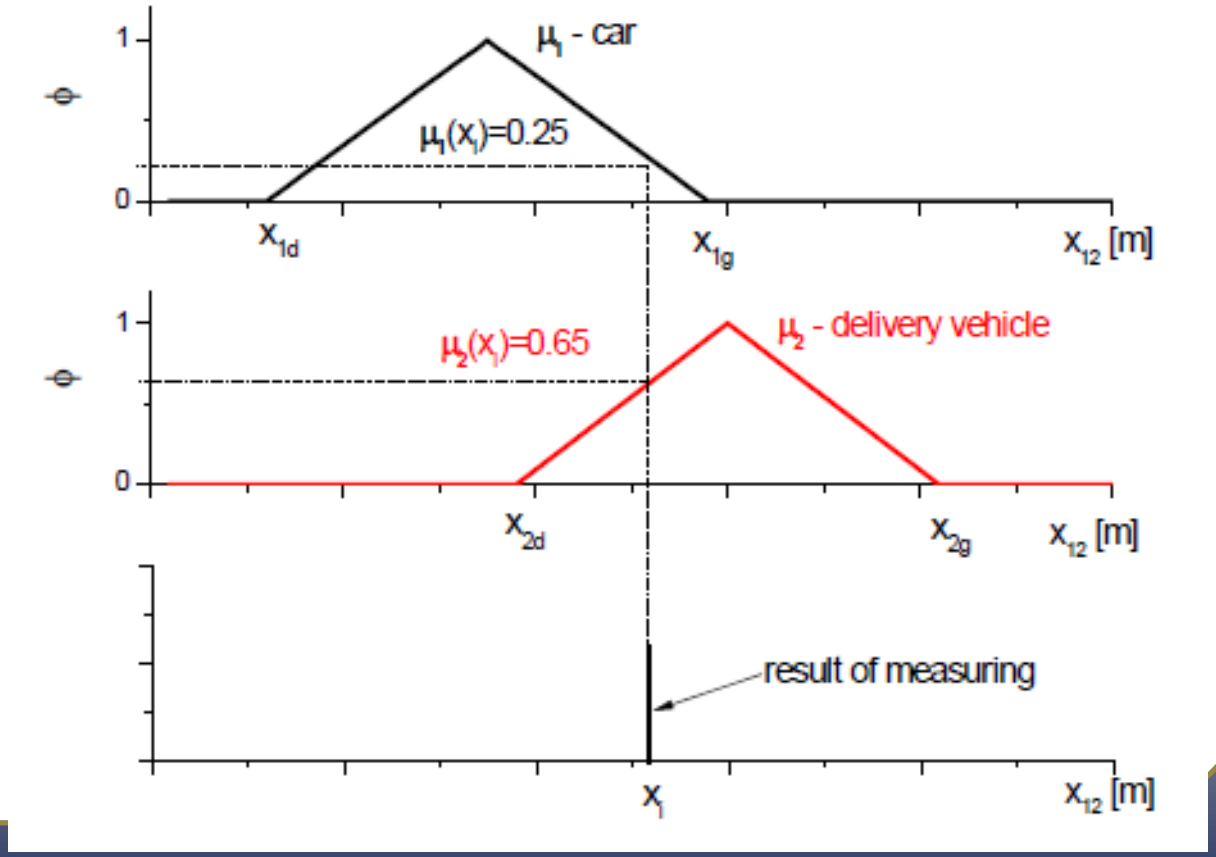
- <u>Middleton (USA):</u>
- US NIST Handbook 44: Amendment proposed on WIM for Enforcement Pre- selection (probable cause)

- Demand from Vendors:
- We urgently need a world WIM standard that is simple and easy to use

Vehicle Classification

Burnos (Poland):

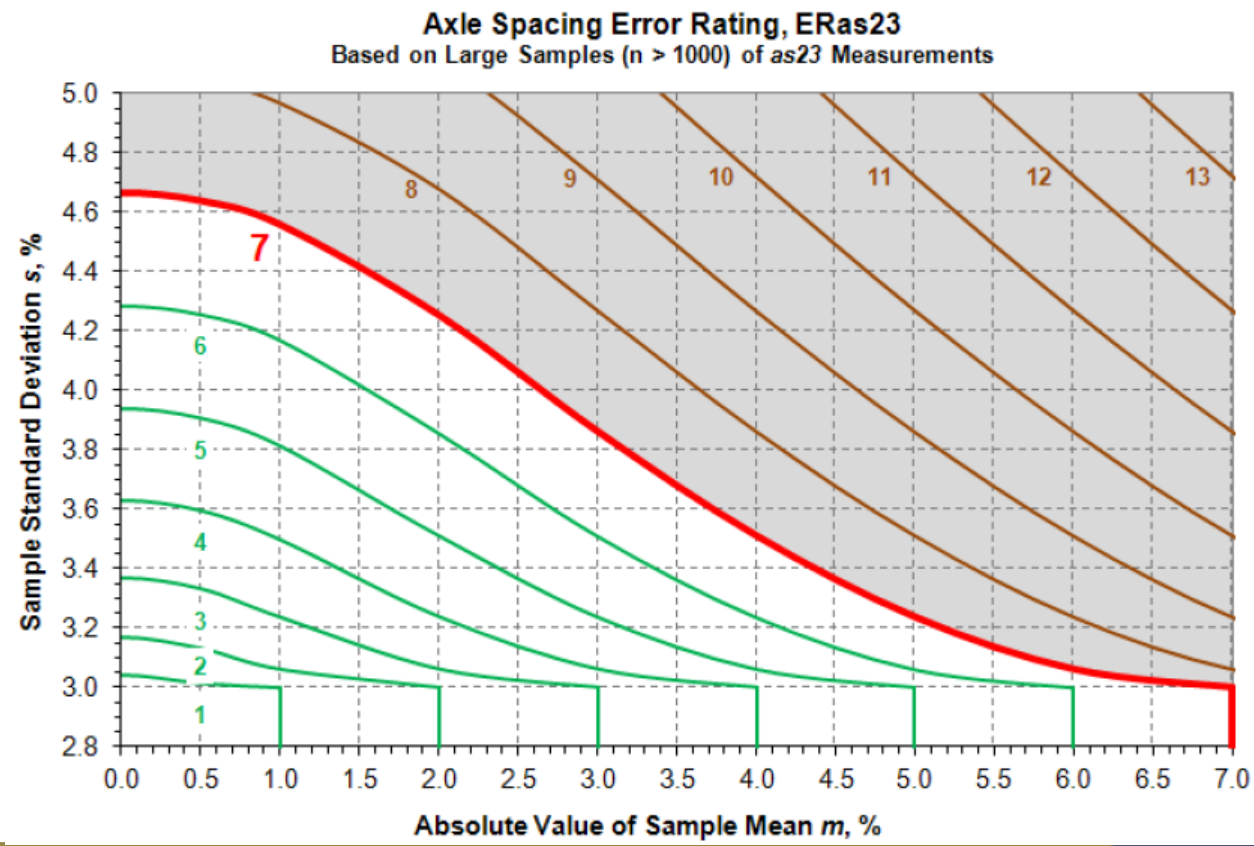
- **Fuzzy logic approach**



Vehicle Classification

DeWet (South Africa):

- **Checking axle spacing data**



WIM Data

- A number of US authors using WIM for Mechanistic Empirical Pavement Design Guide (MEPDG)
- What is the rest of the world doing about 'default values'?

<u>Walker (USA):</u>

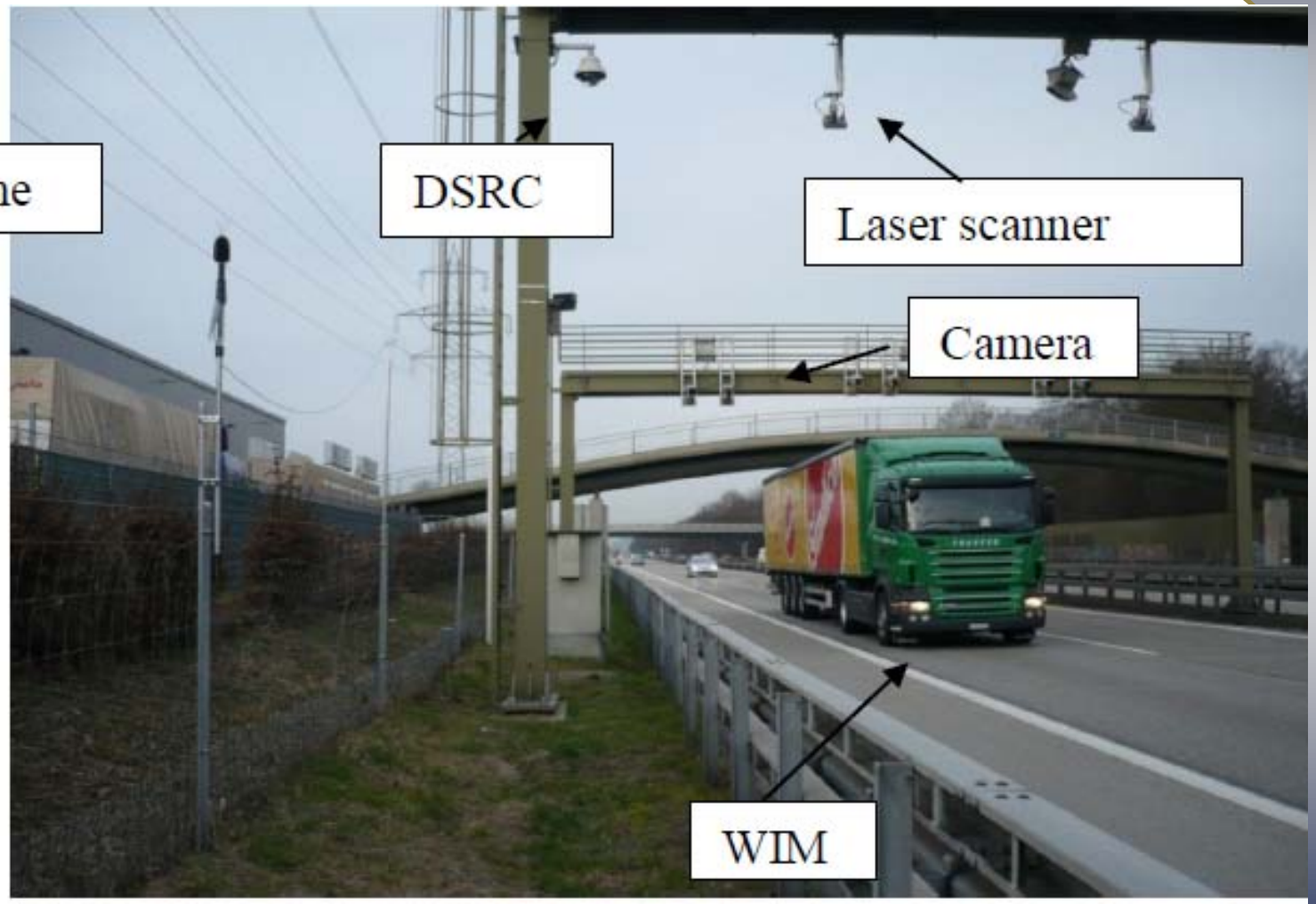
- LTPP project is still going on:
- Hundreds of terrabytes of data
- Traffic Pooled Fund Study
- Top quality WIM data from 28 sites
- 148 site- years of data

Holistic Approach to Data

Poulikakos (Switzerland):

- Environmental footprint of freight
- Swiss Heavy Vehicle Fee
- Honor system – vehicle declares its own weight and pays accordingly
- System checks what they have declared

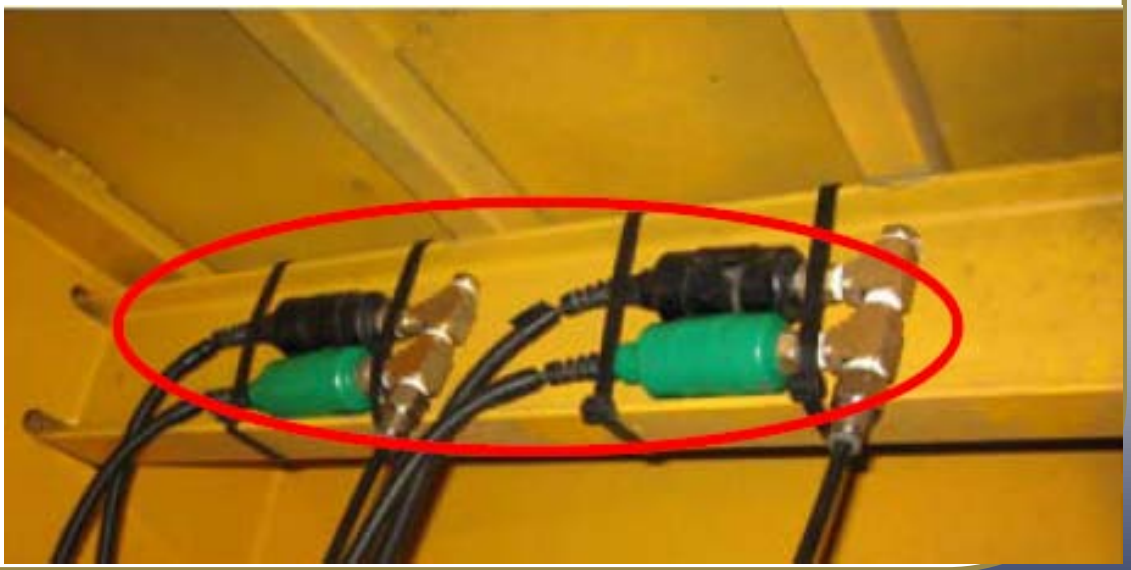
Holistic Approach to Data



On Board WIM

Koniditsiotis (Australia):

- Voluntary system – hauliers can opt in
- Constant monitoring of location and weight
- Monitoring pays for itself in 2 weeks
- Calibration required every 3 months
- Anti- tamper software
- Less than 2% error range



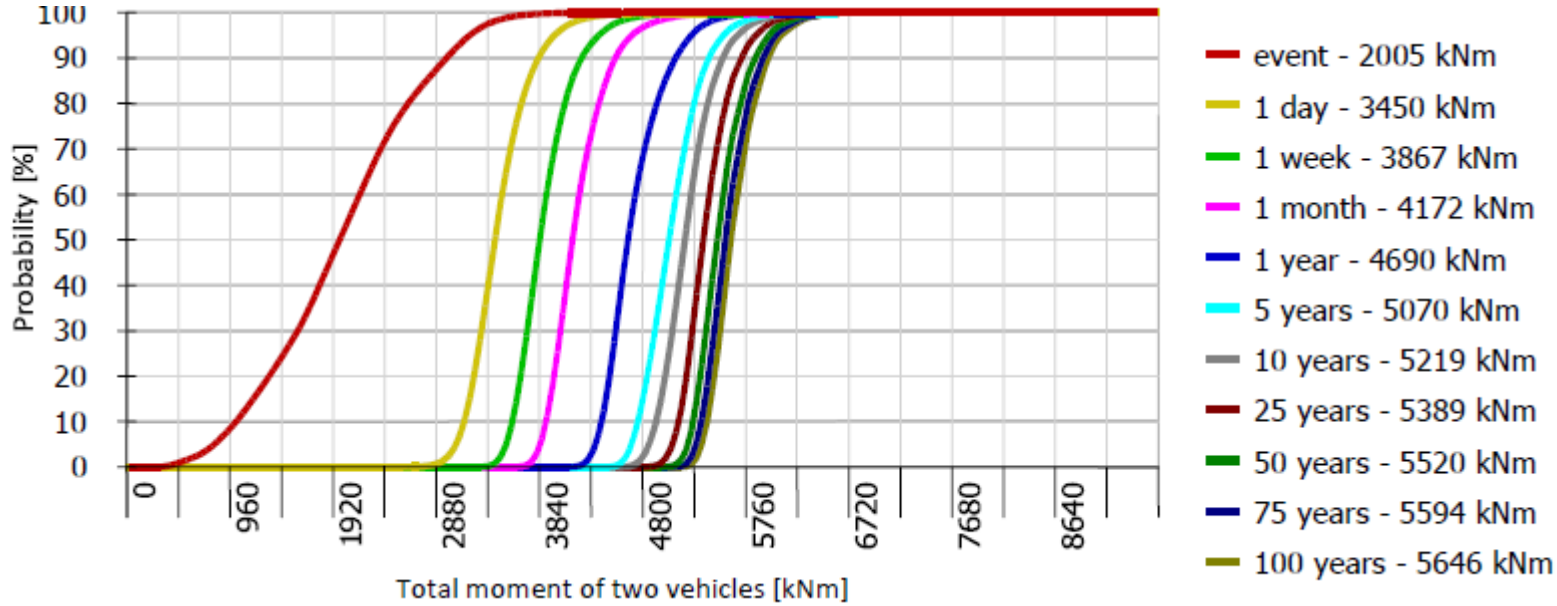
On Board WIM

- And it has a permit!

Bridge Applications of WIM

- **Christensen (USA); Kosnik (USA): Combined Structural Health Monitoring & Bridge WIM**

- **Rakoczy (USA); Znidaric (Slovenia); OBrien (Ireland); Schmidt (France): Statistical methods of load rating for bridges**



Bridge Applications of WIM

- <u>Leahy (Ireland):</u> WIM data collection strategy for bridges on 2^{ary} roads

(a) Category 0

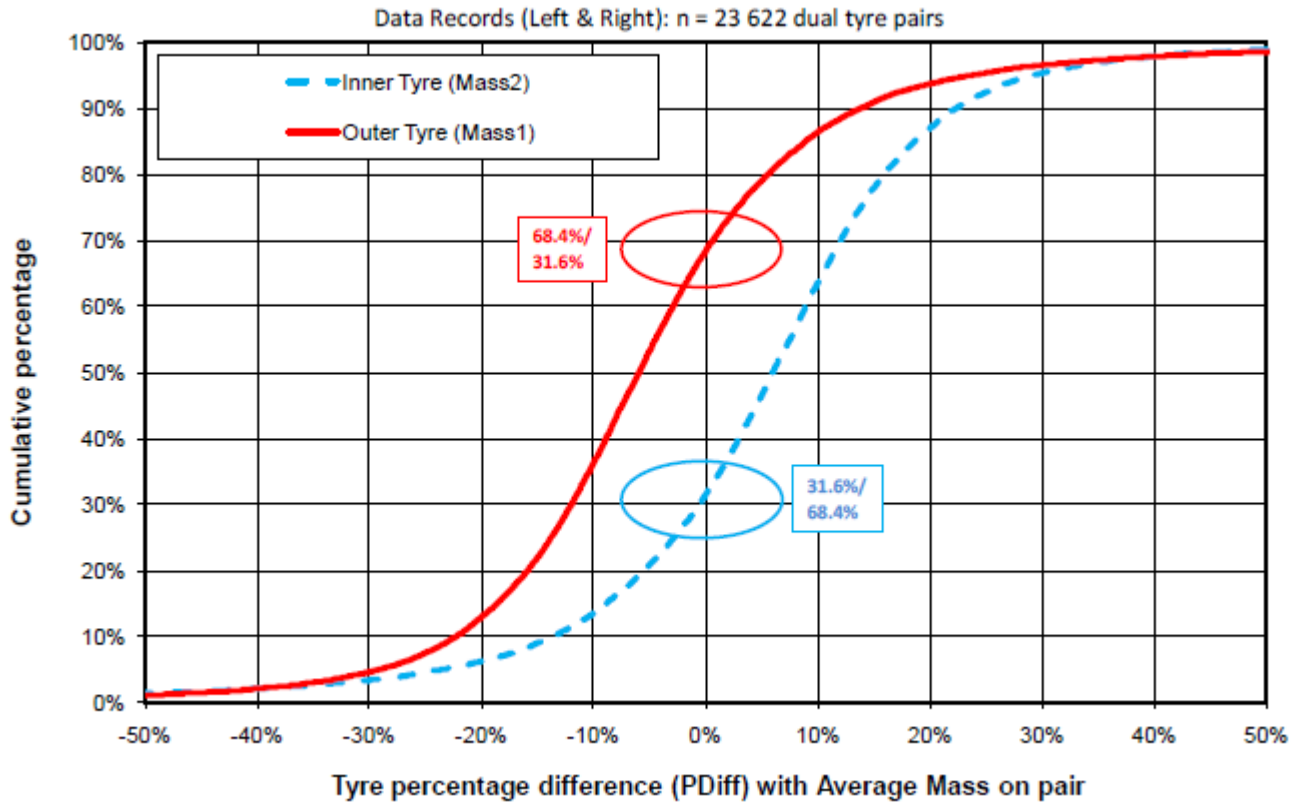
(a) Category 1

(a) Category 2

Pavement Application of WIM

DeBeer (South Africa):

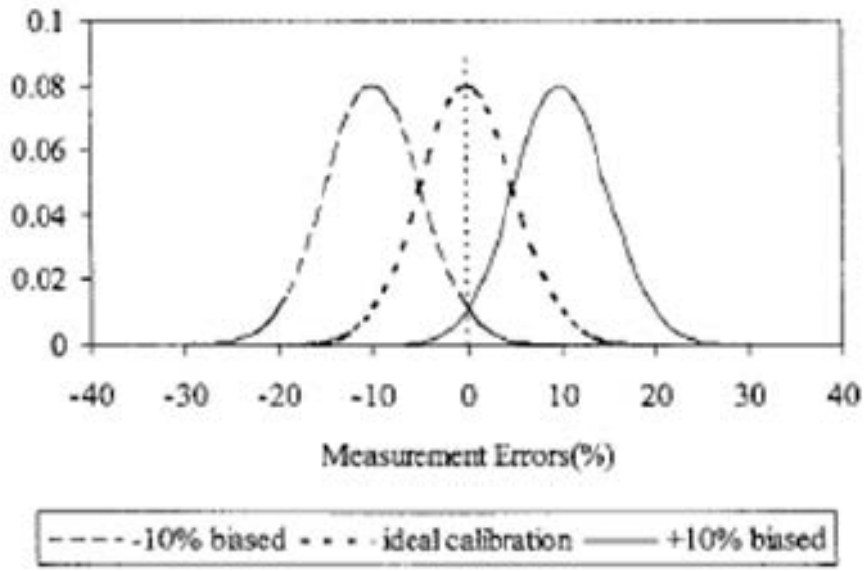
- **Tire Forces and Pressure Footprints**



Pavement Application of WIM

Poulikakos (Switzerland):

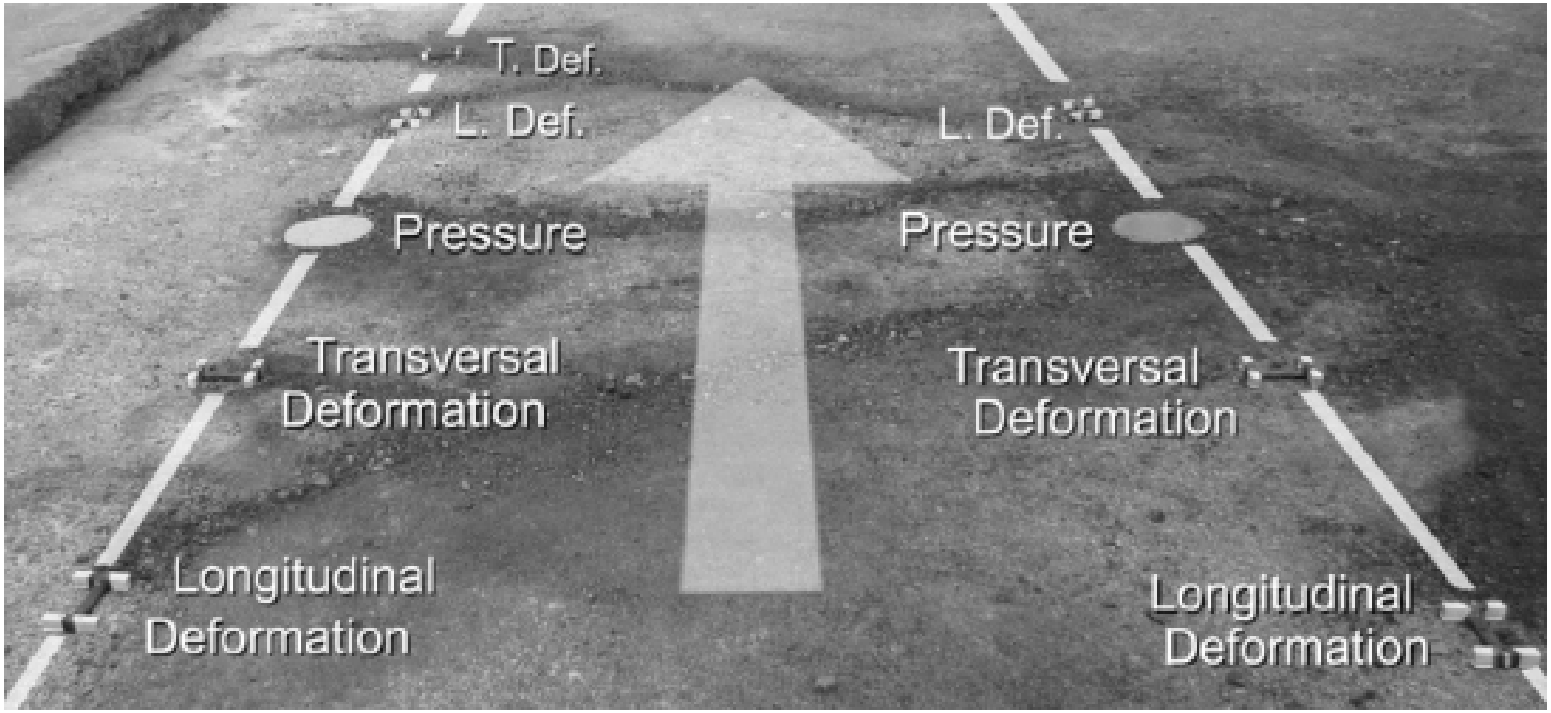
- **10% over- estimating error in WIM ⇒ 51% over-estimate of load on pavement**
- **10% under- estimating error in WIM ⇒ 31% under- estimate of load on pavement**



Pavement Application of WIM

Otto (Brazil):

- **Extensive pavement field instrumentation, including WIM, in Brazil**



Conclusions

- ISWIM and FHWA should develop a 'WIM 101' Tutorial to tell beginners what WIM is

- Pre- selection for Enforcement – keep the legal trucks moving!
- Very exciting things happening in Czech Rep.
- Australian system seems like a great idea

Conclusions

- MEPDG: What about default inputs for the rest of the world?
- Bridge Load Assessment: We need vehicle- by- vehicle data and time stamps to 0.01 second
- We need a simple, easy- to- use WIM standard