



Laboratory and Field Evaluation of Piezoelectric WIM Sensors

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Acknowledgments:

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Objective:

Evaluate the following piezo sensors:

- Vibracoax 3mm encapsulated
- Vibracoax 8 mm bare
- MSI Roadtrax BL (not encapsulated) and
- MSI Roadtrax BLC (encapsulated)



Tasks:

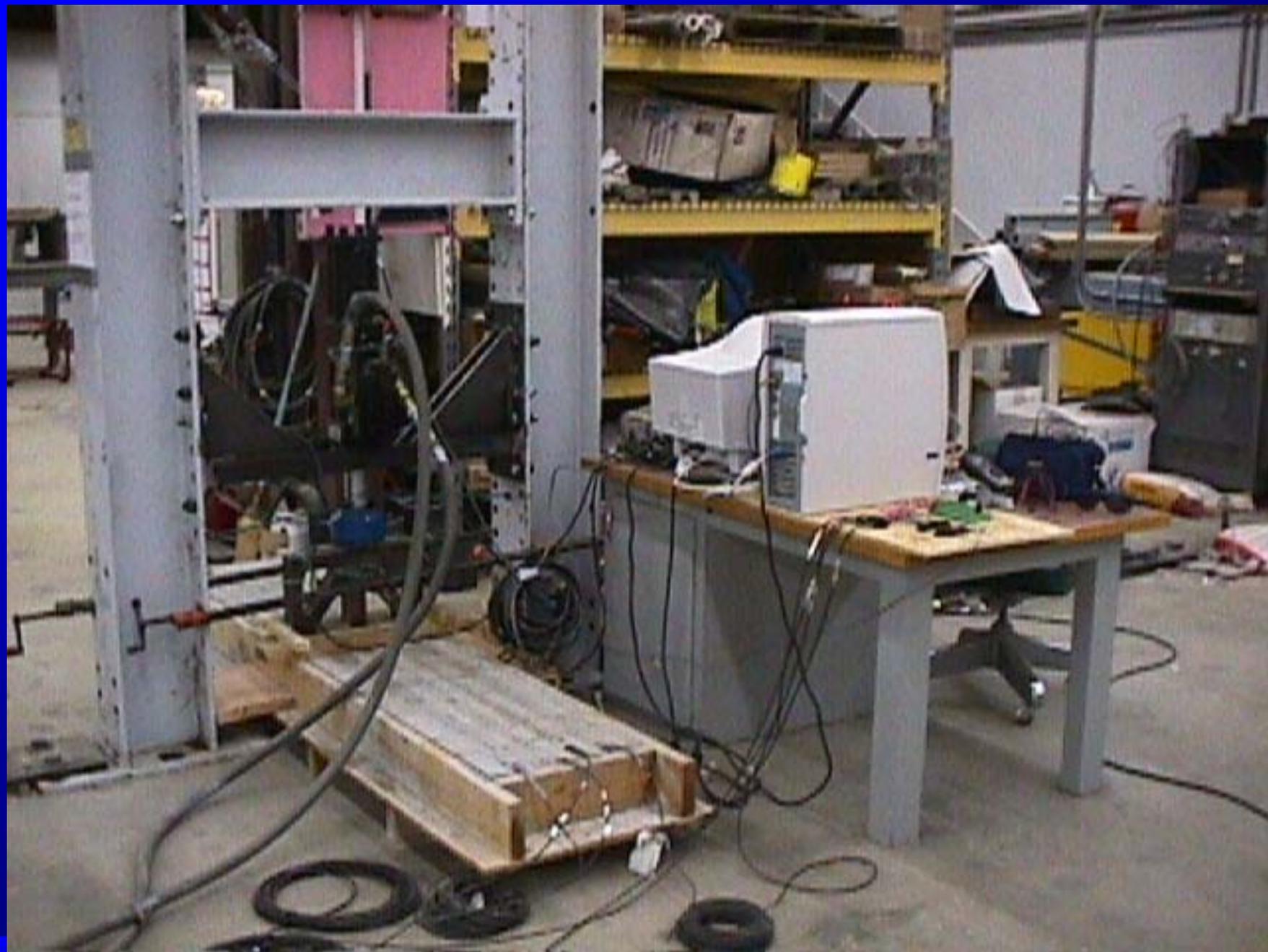
- Fatigue testing in the laboratory.
- Field performance in asphalt pavement (WesTrack).
- Field performance in concrete pavement (HVS)

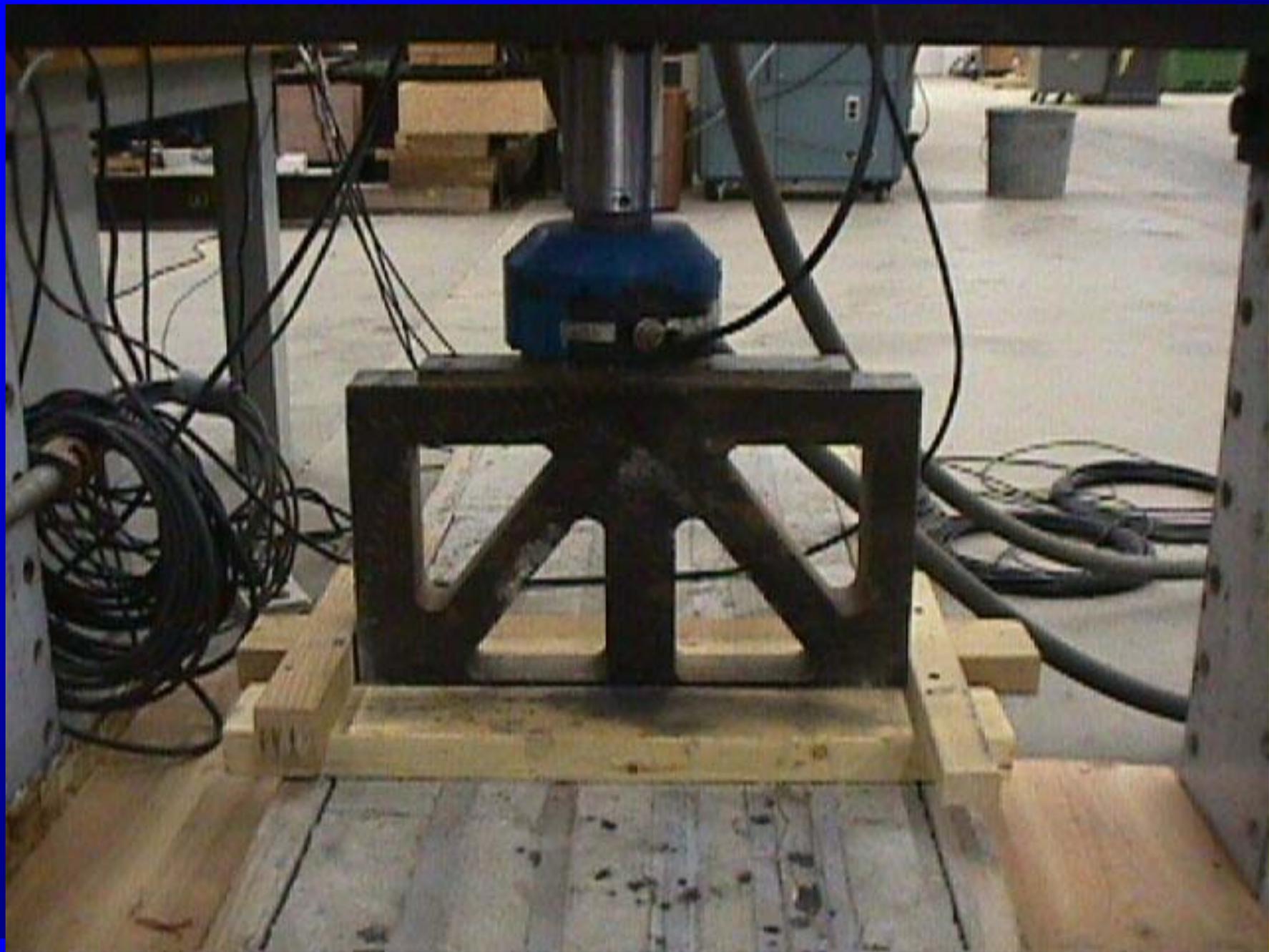


Laboratory Testing:

- ☞ Concrete slabs and ECM epoxy.
- ☞ Each sensor was tested under:
 - 860 kPa under dry conditions
 - 860 kPa under wet conditions
 - 200 kPa under dry conditions
- ☞ Loading frequency of 4Hz.

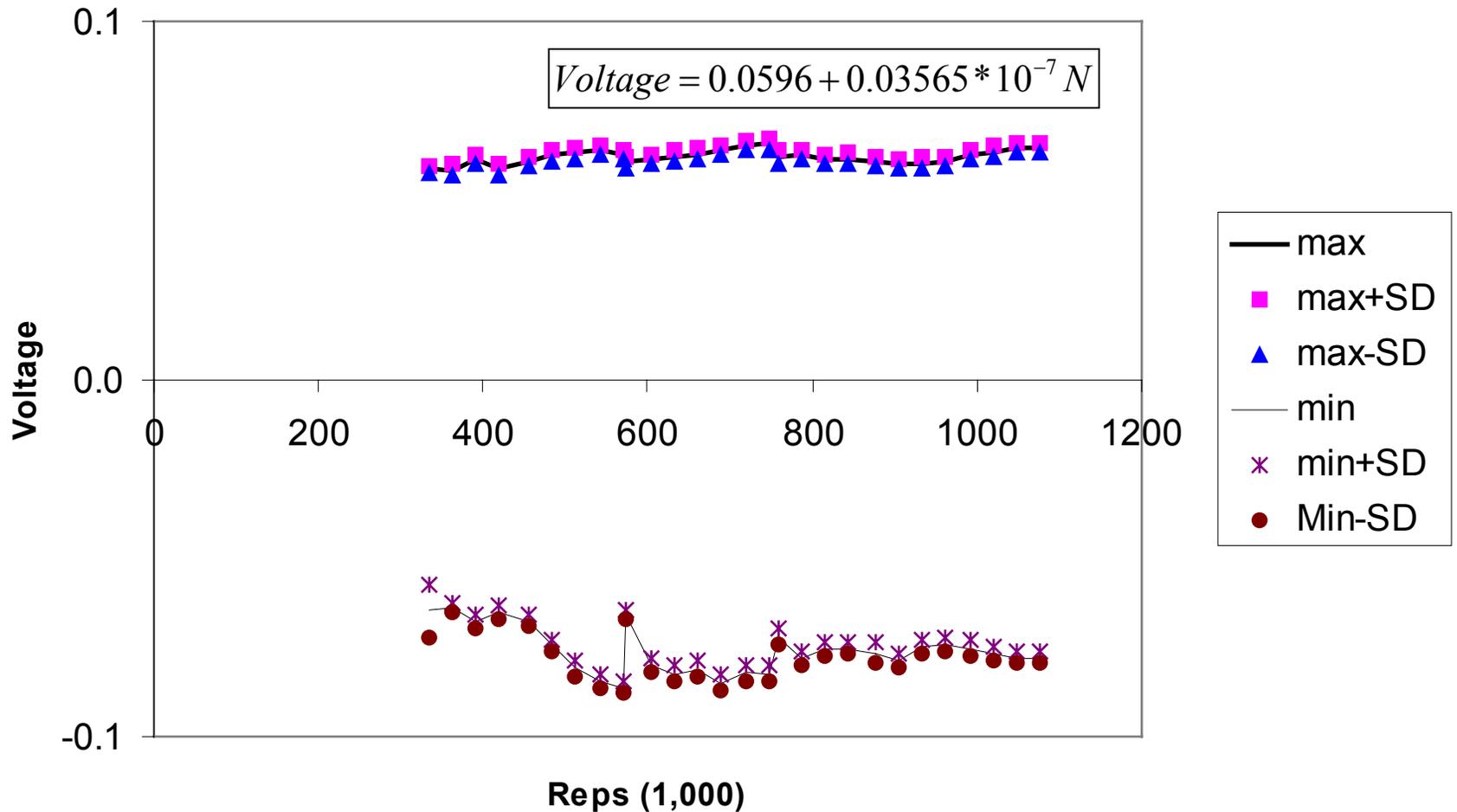






VC-encapsulated; 860 kPa, Dry.

Manufacturer A- Encapsulated



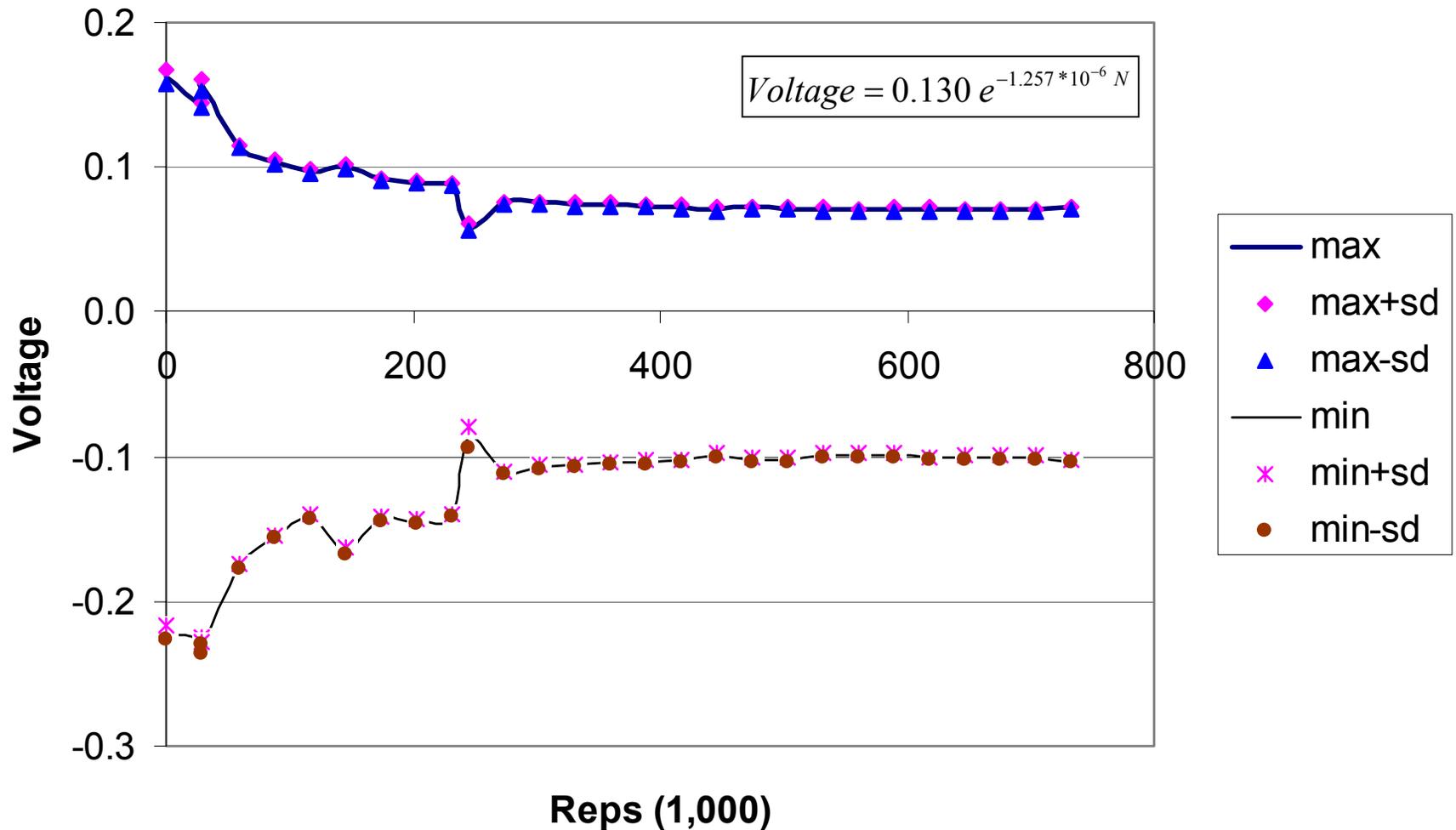
MSI-encapsulated; 860 kPa, Dry

Manufacturer B- Encapsulated



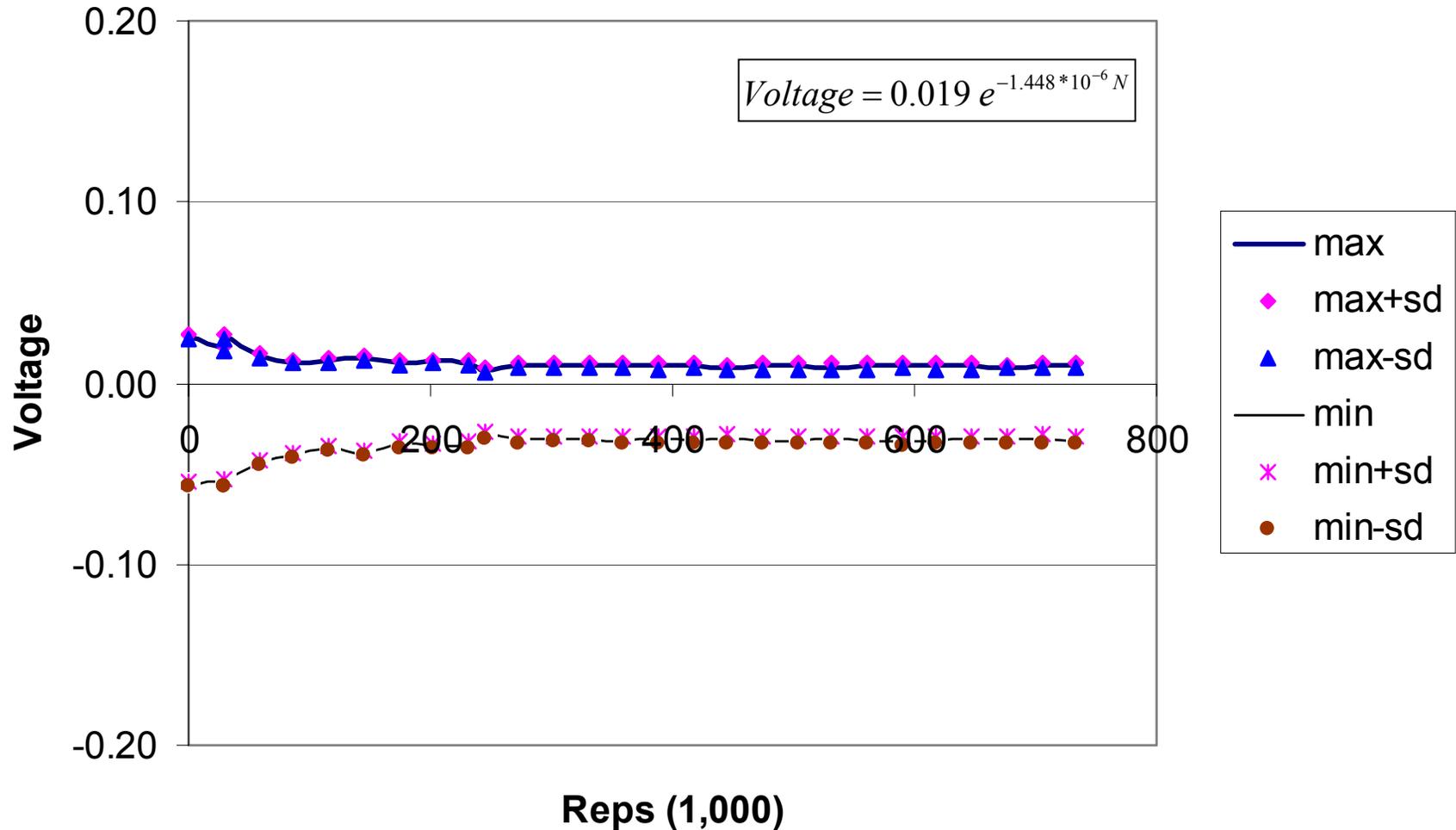
VC-encapsulated; 860 kPa, Wet

Manufacturer A- Encapsulated



MSI-encapsulated; 860 kPa, Wet

Manufacturer B- Encapsulated



Laboratory Findings:

- ☞ Some short-term changes in voltage output.
- ☞ Under 860 kPa/dry:
 - both types of VC sensors exhibited an increase in peak voltage output, while,
 - both types of MSI sensors exhibited a decrease in peak voltage output.
- ☞ Under 860 kPa/wet:
 - both makes of encapsulated sensors outperformed the bare sensors
- ☞ Under 200 kPa/dry:
 - No apparent fatigue damage for any of the sensors



Asphalt Concrete Field Testing:

- 16 WIM sensors:
 - 12 for loading tests
 - 4 for compatibility tests
- 5 different installation grouts
- 183,000 ESALs applied
- Collect:
 - WIM data (Hestia DAQ) and,
 - periodically raw signal



WesTrack Installation:



Hestia Data Acquisition System

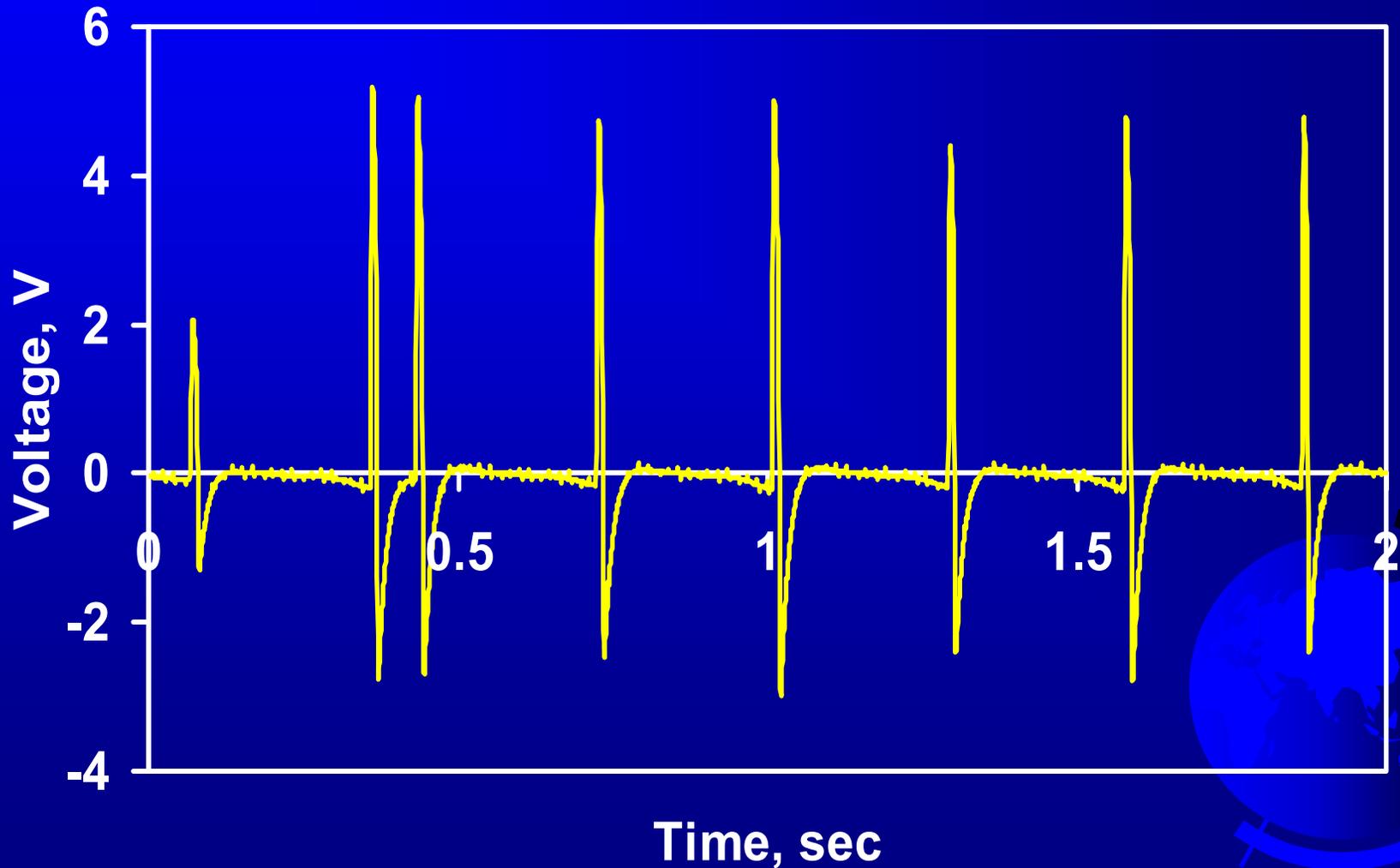


WesTrack Vehicle: 7x89 kN axles



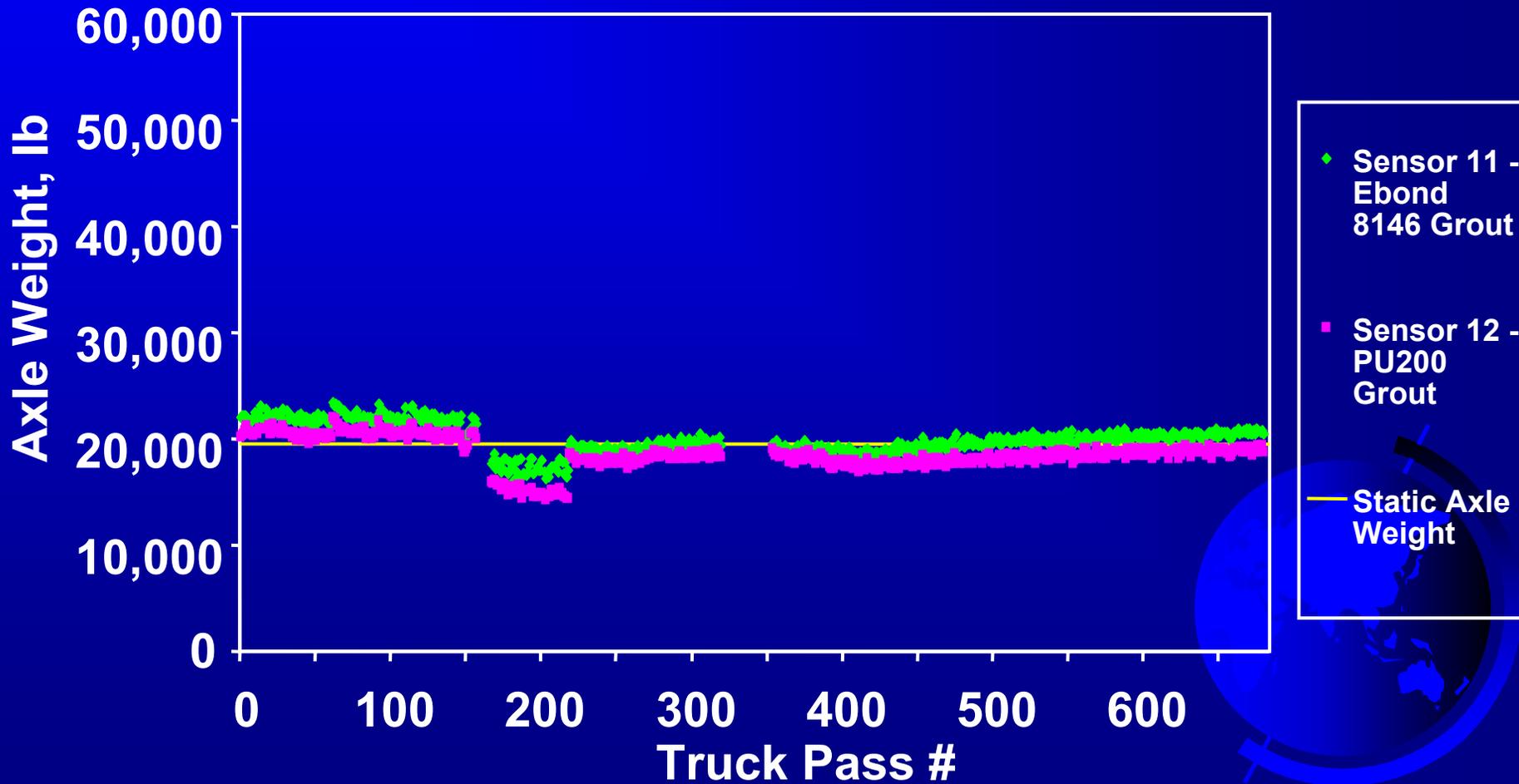
Raw Signal Example; MSI

Sensor 11 Roadtrax BL, 12/18/98



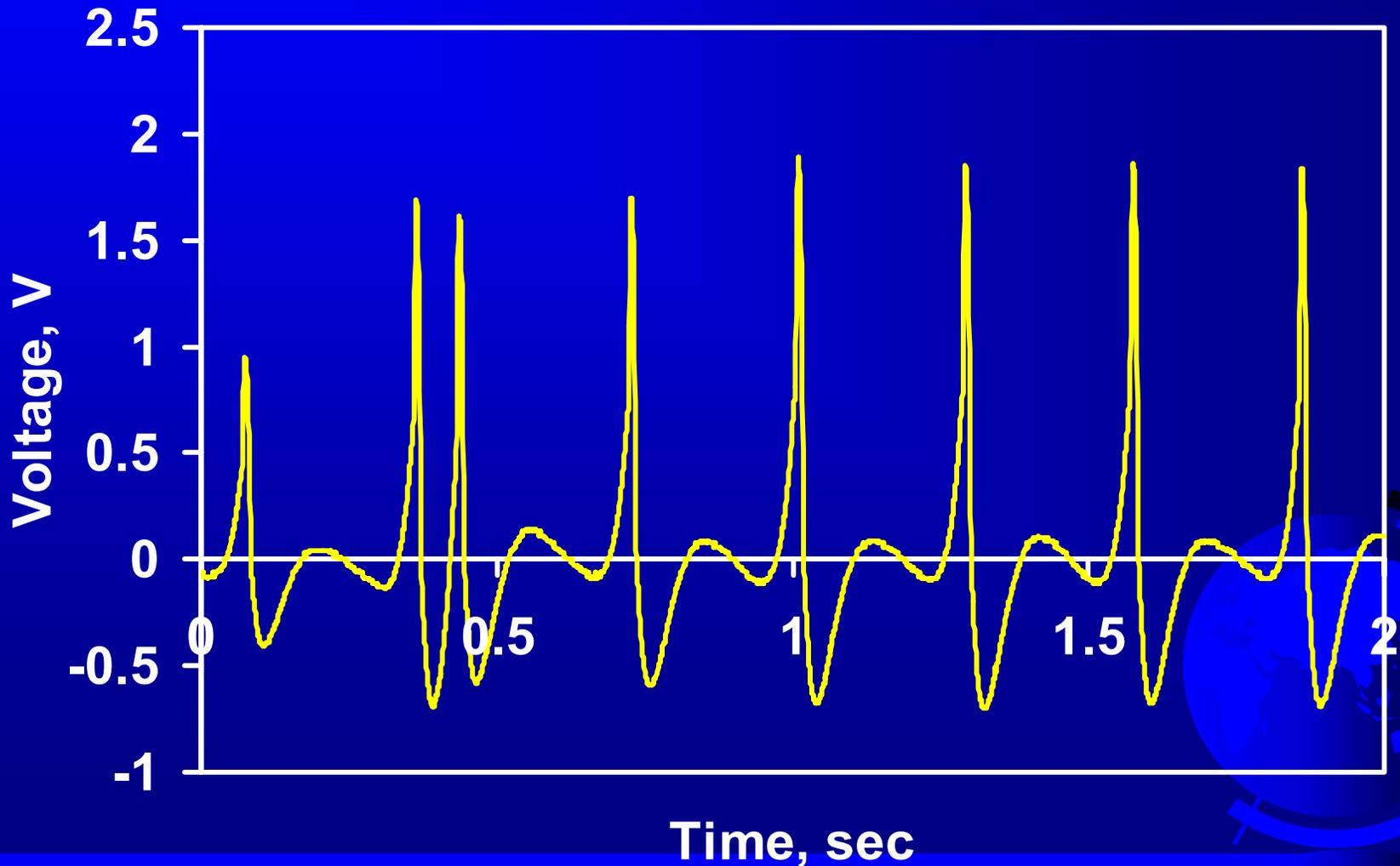
WIM Measurement Example, MSI

WIM Measured Axle 3 Weight, Roadtrax BL



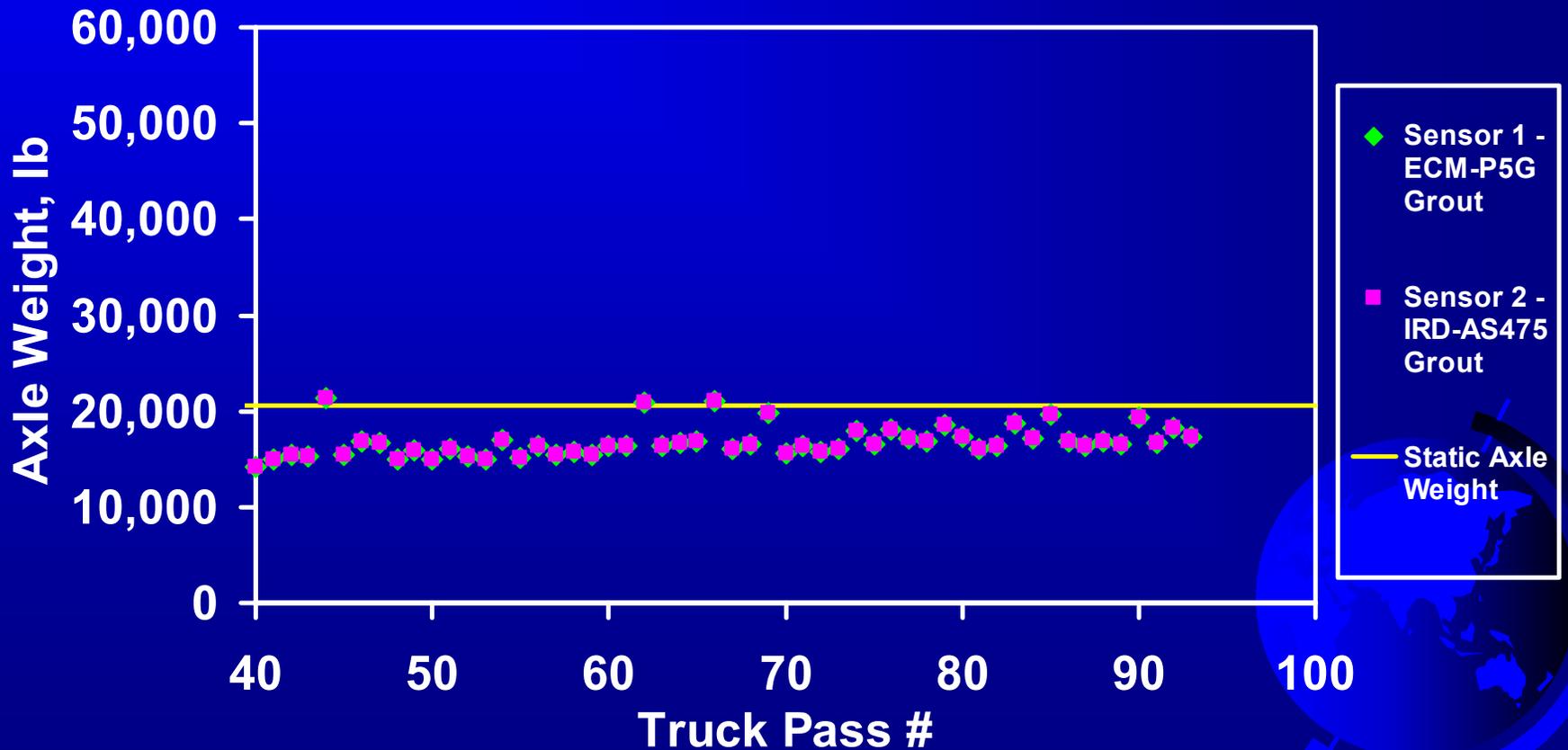
Raw Signal Example, VC

Sensor 1 Vibracoax Bare, 12/17/98



WIM Measurements Example; VC

WIM Measured Axle 2 Weight, Vibracoax 3mm Bare
(After Hestia Adjustment)



WesTrack Test Findings:

- Raw signal was very precise over the short-term but appeared to be temperature sensitive. For increasing temperature:
 - it decreased for the VC sensors, while,
 - it increased for the MSI sensors.
- Fine-tuning the raw signal reduction routine in the DAQ to compute WIM weight required several iterations.
- After fine-tuning, WIM data was very precise.



Portland Concrete Field Testing:

- HVS Facility operated by CalTrans
- Evaluate raw signal performance only (speed=11 km/h):
 - Uniformity Along Length
 - Moisture Resistance
 - Sensitivity versus load cycles/failure
- Signal/Noise ratio
- Adherence of grouts



Experimental Design:

- 10 sensors (8 loaded, 2 off-axis)
- Environmentally controlled ($\approx 20^{\circ}\text{C}$)
- $\approx 600,000$ repetitions applied with loads increasing from 40, 60 to 90 kN
- ≈ 3.2 million ESALs



The HVS:



Sensors under HVS loading:



The Data Acquisition System



S/N Ratio Results:

Approx. ESALs	Sensor							
	VC-e	VC-b	VC-b	VC-e	MSI-e	MSI-e	MSI-e	MSI-b
4,000	53	53	100	105	114	118	94	70
465,000	63	83	11	157	223	195	32	147
1,400,000	73	78	12	22	175	198	30	113
2,730,000	68	73	17	25	170	193	43	115



HVS Test Findings:

- S/N ratios very strong for all sensors, but grout seemed to affect its magnitude.
- Although raw signal did not have the shape experienced at higher speeds, its precision was excellent.
- No reduction in signal was experienced with increasing number of axle passes.





More in TRB Record 1769
and CERF Reports No. 40586 and 40587

Questions?