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A DEPARTMENT OF HOMELAND SECURITY CENTER OF EXCELLENCE

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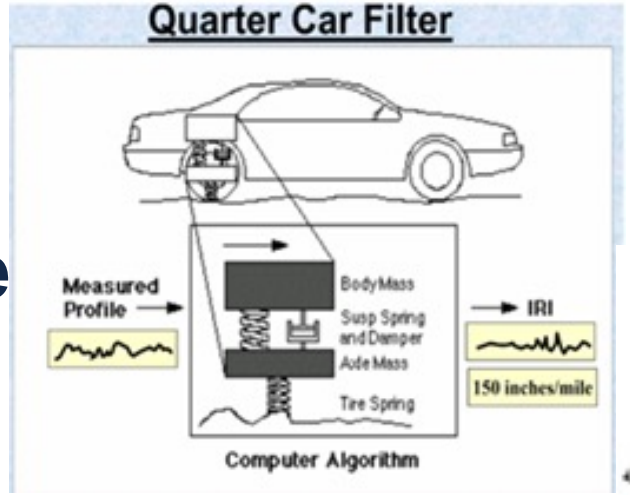
Integration of Vehicle-Based Sensing and Vehicle Dynamic Model for Evaluating Highway Infrastructure Resilience

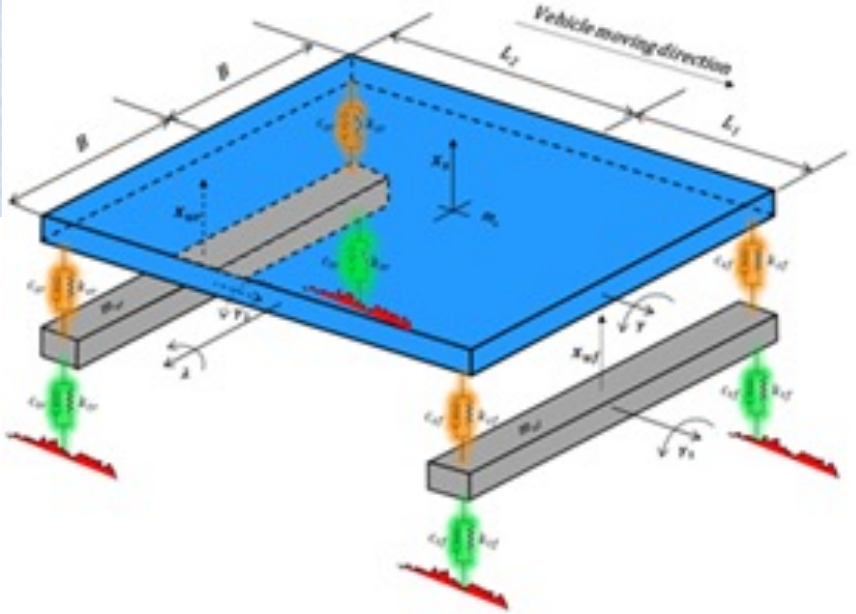
Research Team Members

- Northern Arizona University:
- Chun-Hsing Ho (PI)
- Jimmie Devany, Manuel Lopez, Jr., (Undergraduate students)
- Illinois Center for Transportation
- Dr. Imad L. Al-Qadi (Mentor)
- Mr. Xiuyu Liu (Doctoral student)

Introduction and Challenge

- Pavement International Roughness Index (IRI) is an important measure of pavement rideability.
- Current IRI has been introduced in 1980's and its theoretical quarter car model has not been updated.





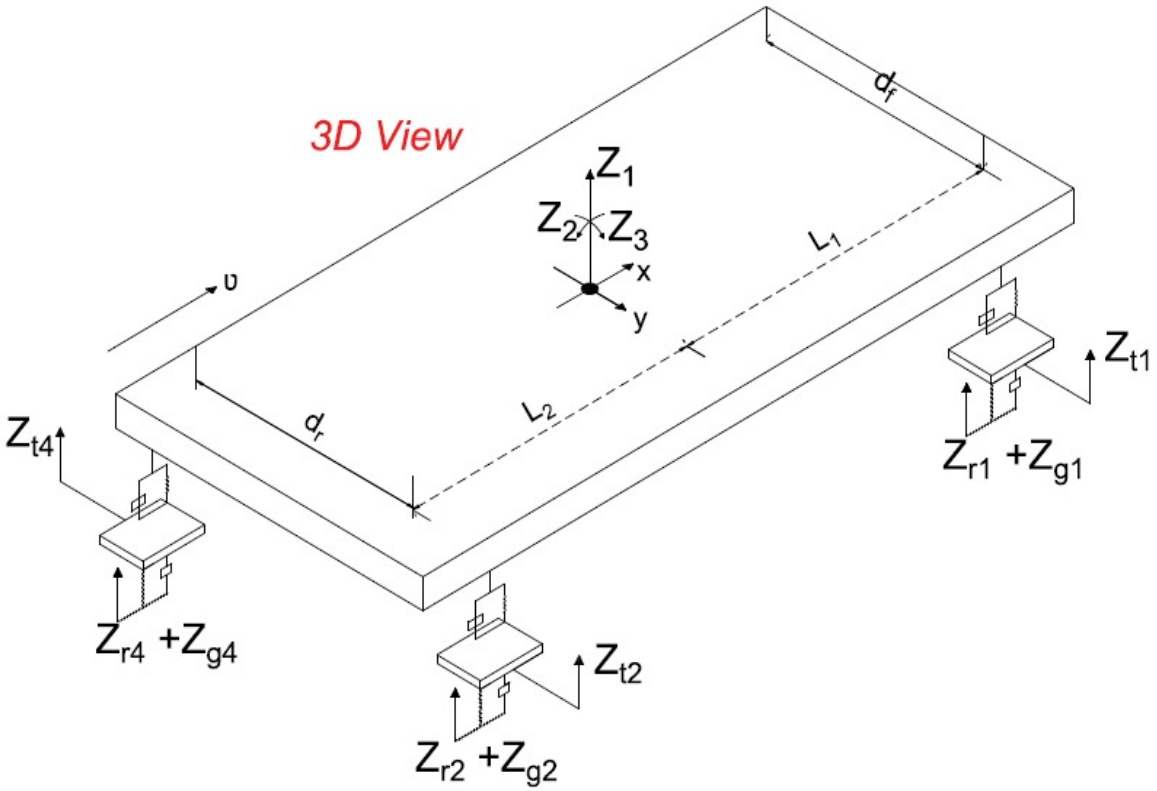
(Curtesy of Al-Qadi and Liu)

Introduction: Vehicle-Mounted Sensors

- Vehicle-mounted accelerometers were developed in the Northern Arizona University laboratory using a sensor logger consisting of triple-axis accelerometers, computer boards, GPS, and a battery

Introduction: Full Car Model

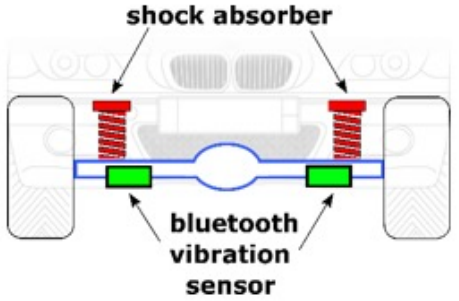
- A full-car model, comprises of two axles and a main vehicle body with seven DOF, has been developed by Al-Qadi and coworkers at the Illinois Center for Transportation of UIUC to estimate pavement roughness based on IRI values

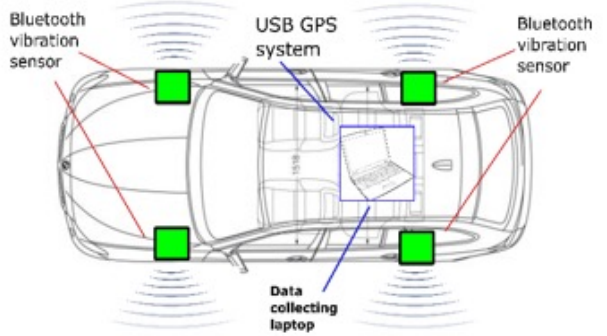


Objectives and Scope

- Overcome quarter-car limitation.
- Propose an integrated system of vehicle mounted accelerometers and a full-car model to predict IRI.
  - Vehicle-mounted sensors and smart phone embedded accelerometers could be a cost effective method

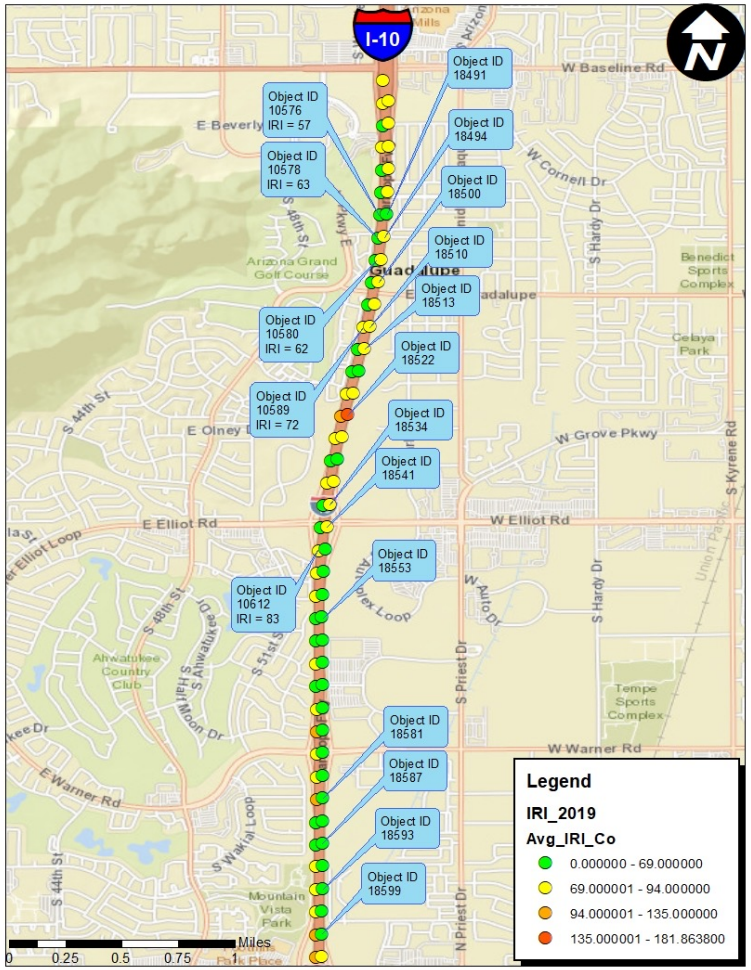
Vehicle mounted sensors



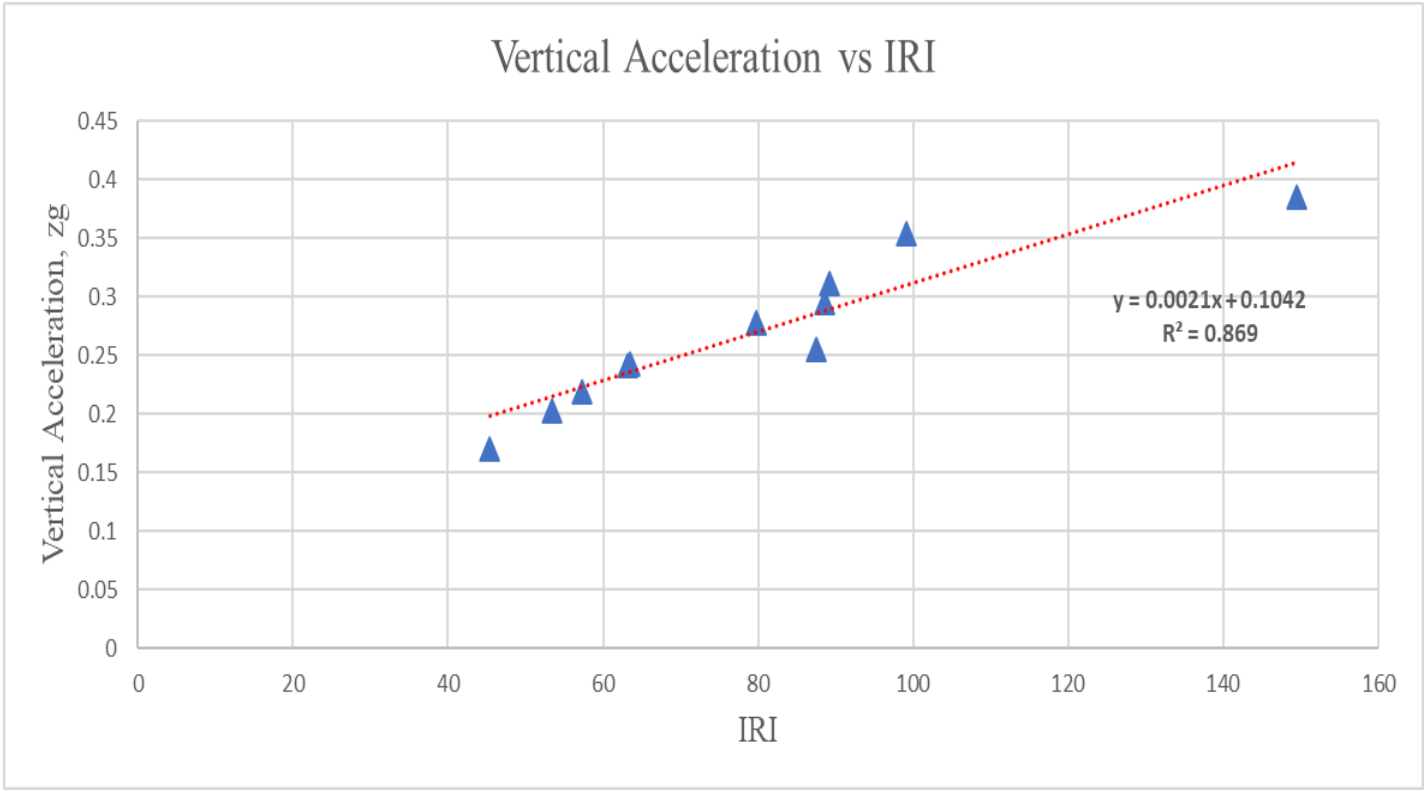


smart phone embedded accelerometer

Data collection and analysis: First trial

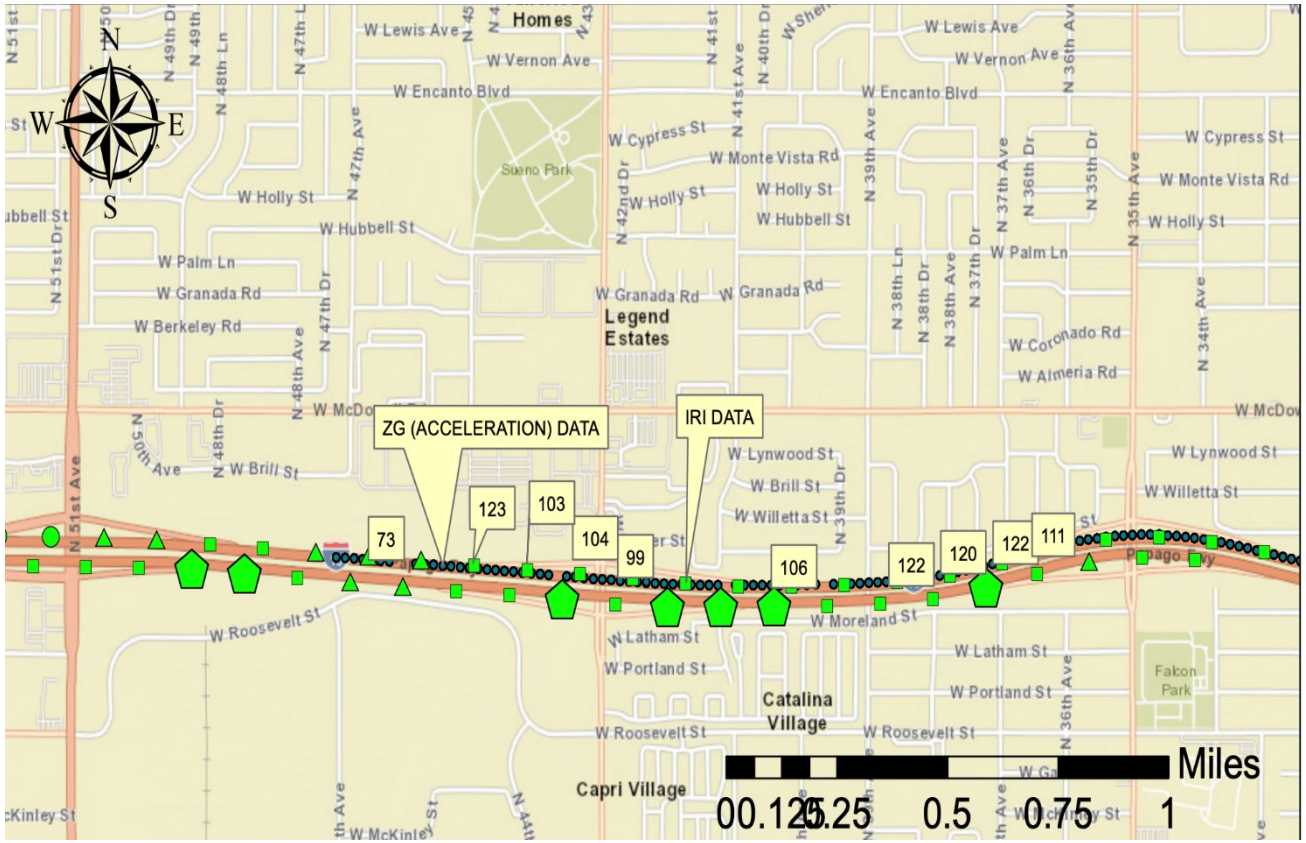


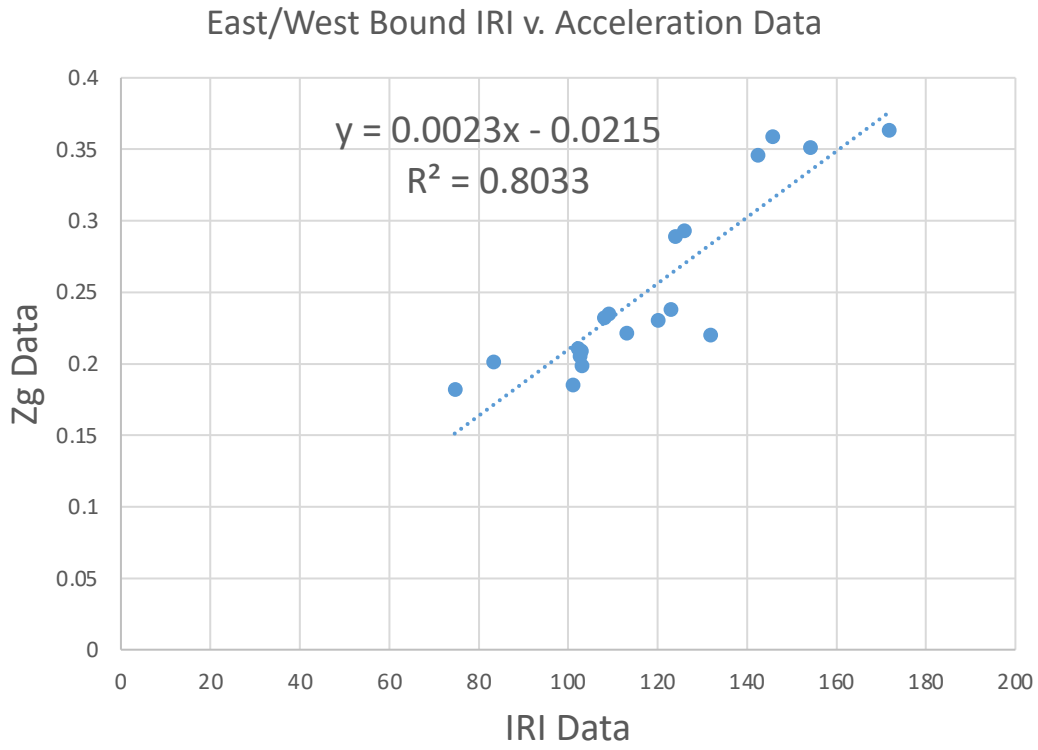
- **Baseline Rd to Chandler Blvd**



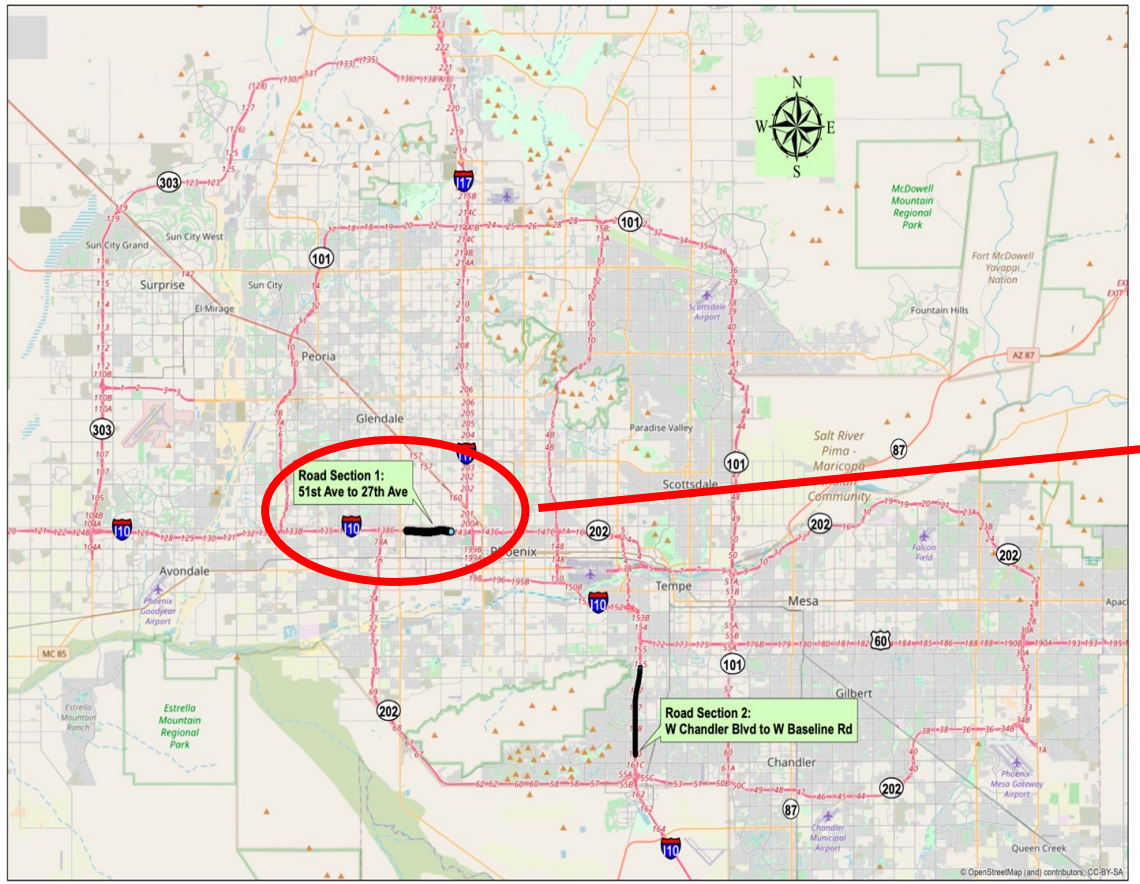
Data collection and analysis: First trial

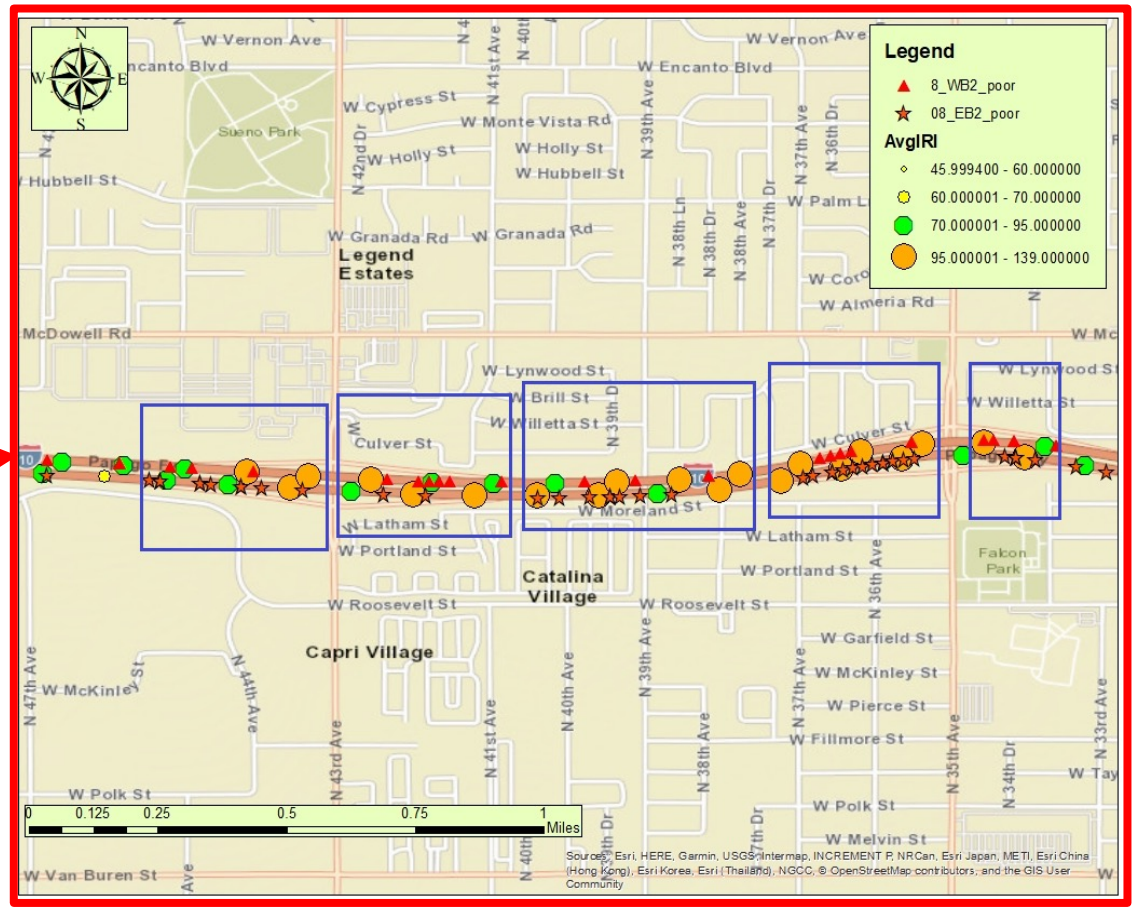
- 27th Ave. to 51st Ave.



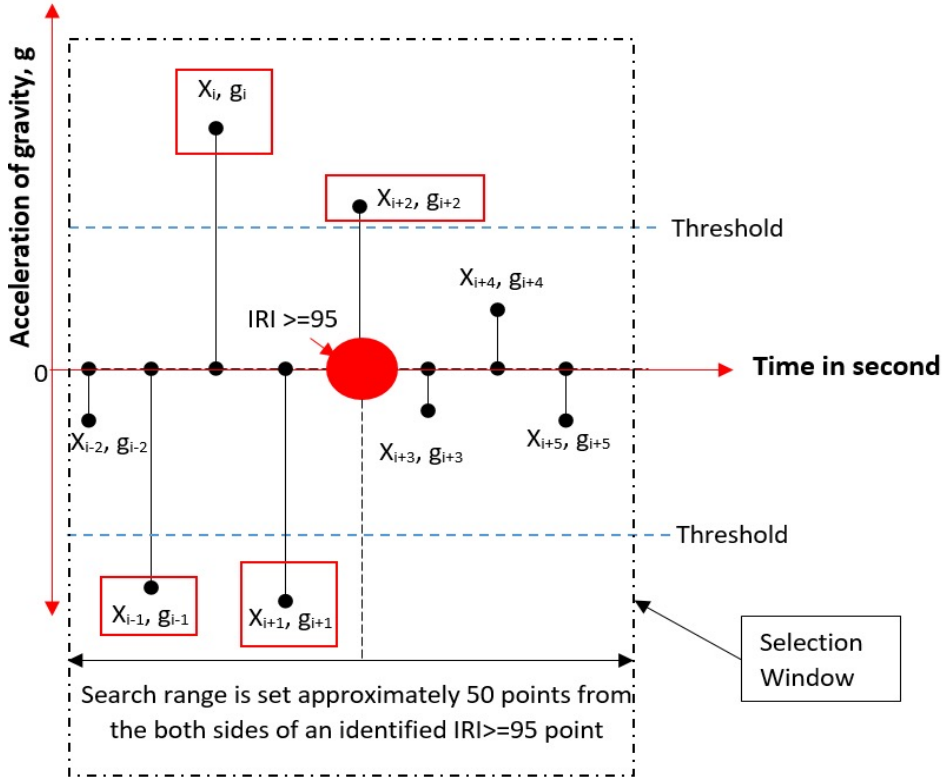


Data Collection on Two I-10 Corridors in Phoenix



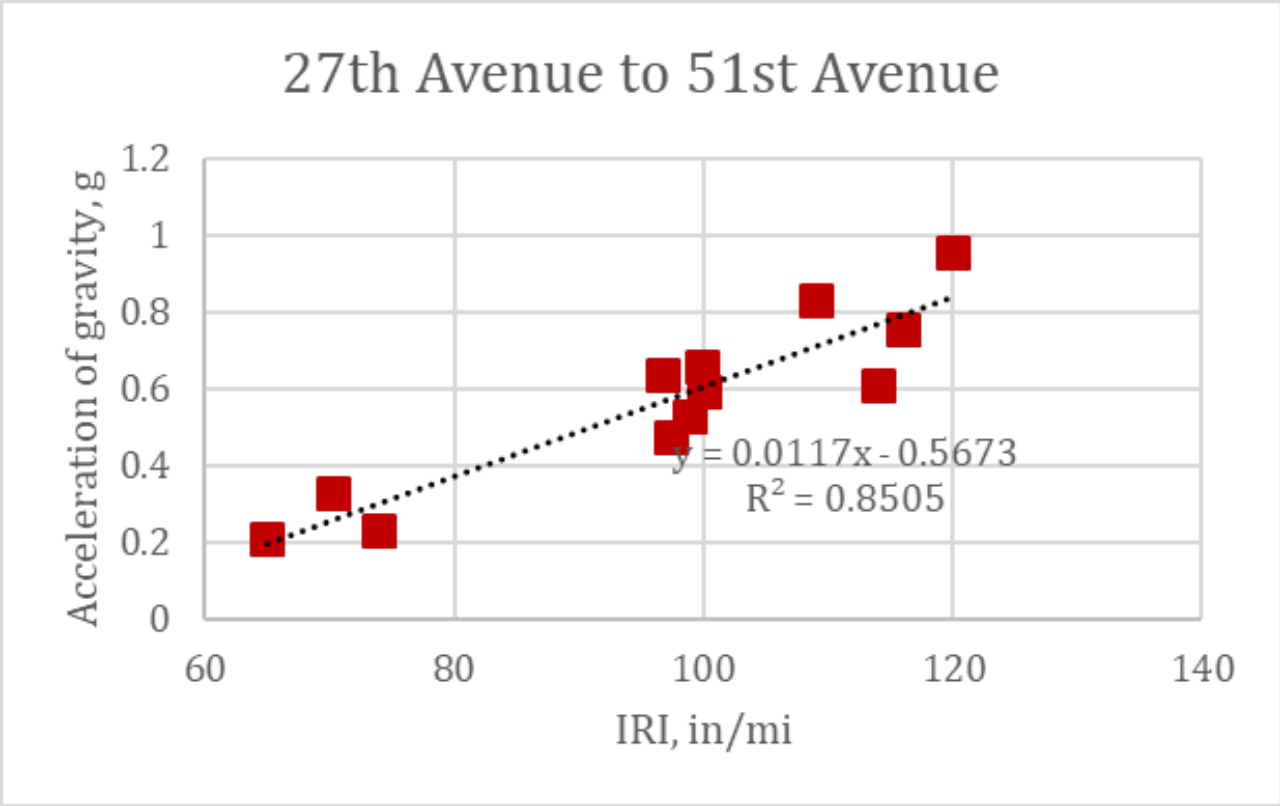


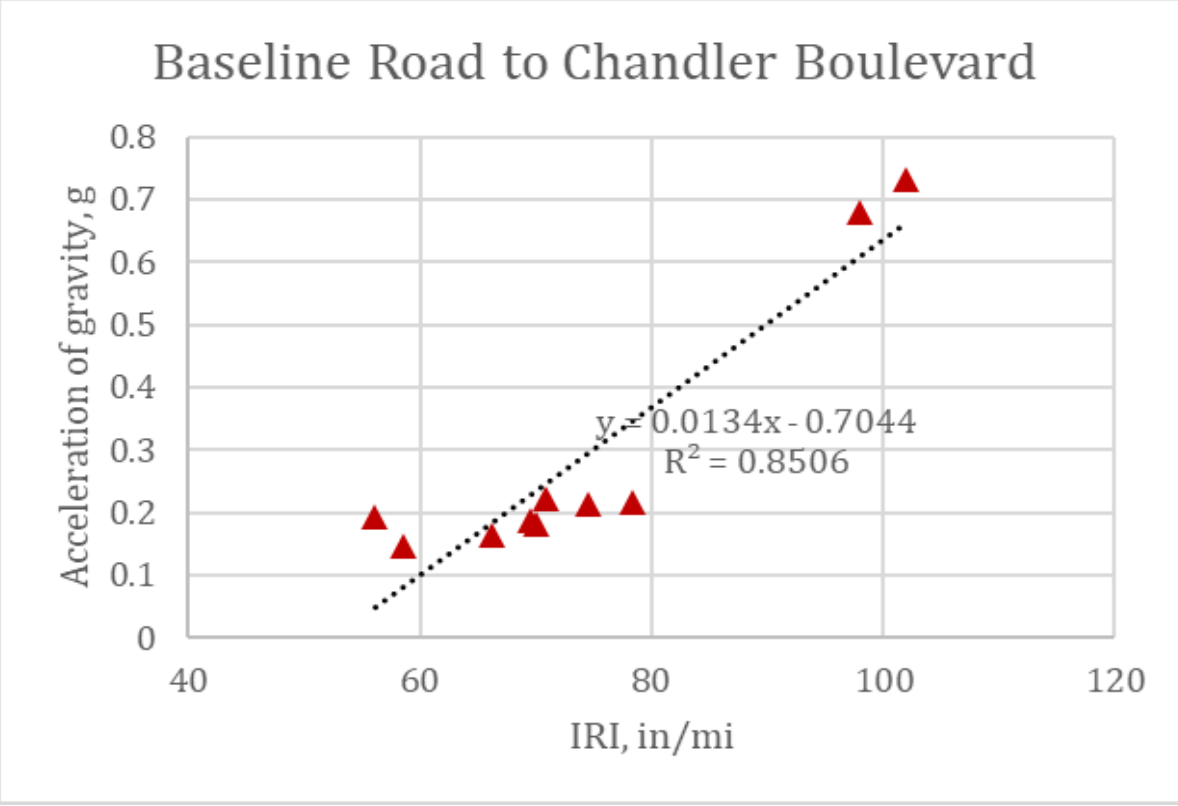
Window Interpolation Method: Data Matching and Selection



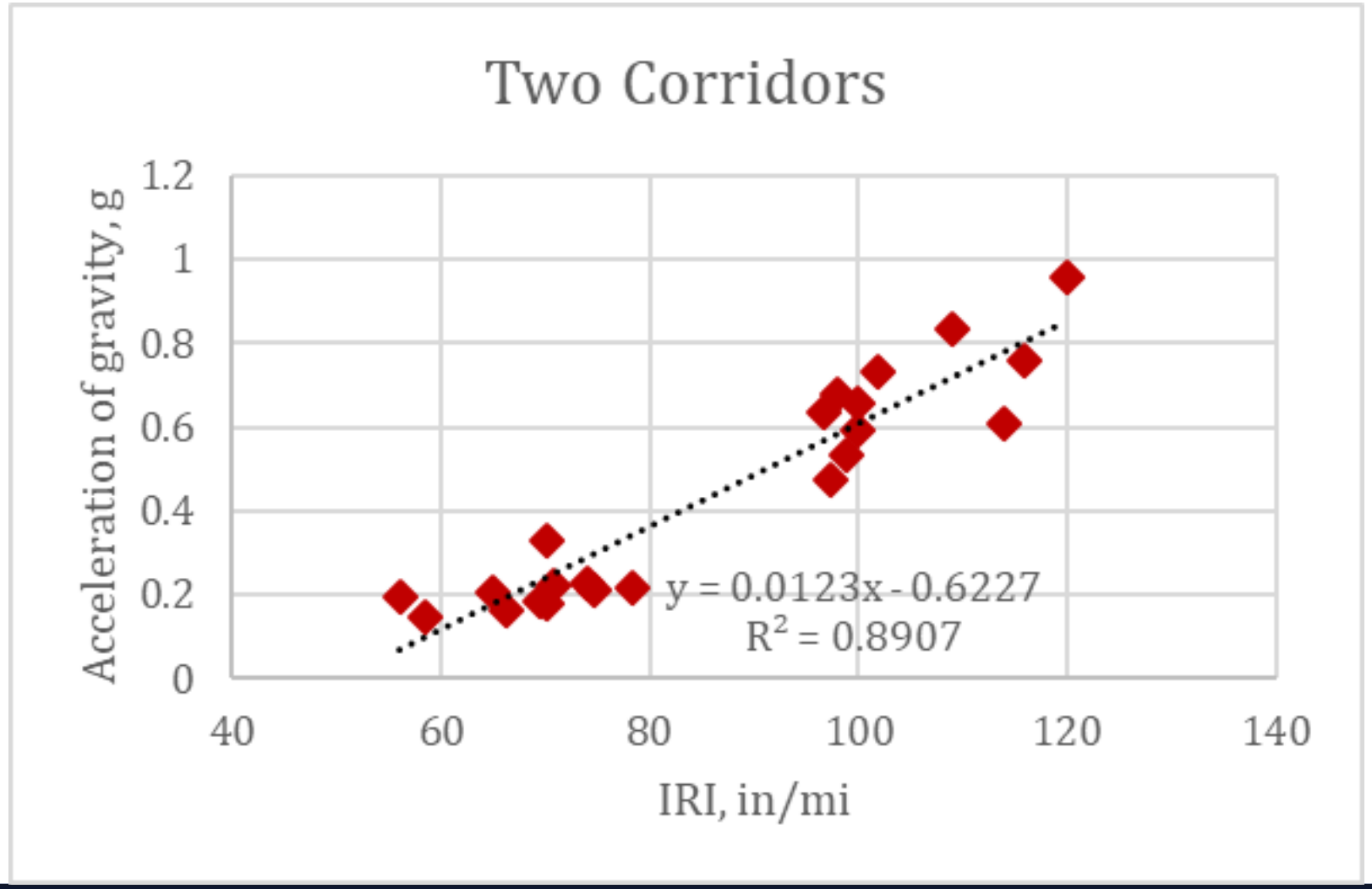
- All selected acceleration points within a "window of IRI" are exported, averaged and recorded, and a table is generated in ArcGIS.

Linear Regression Results



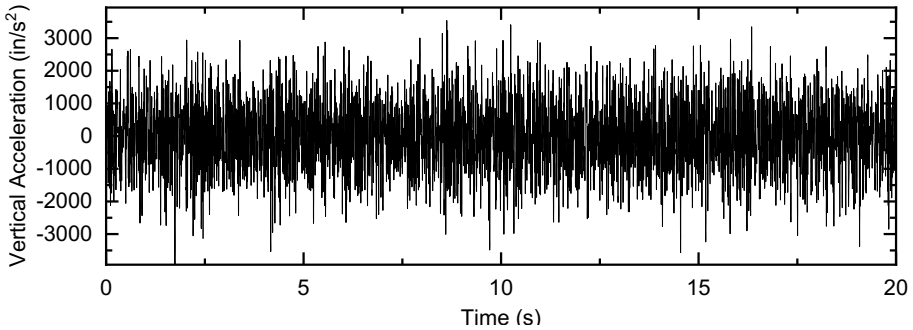


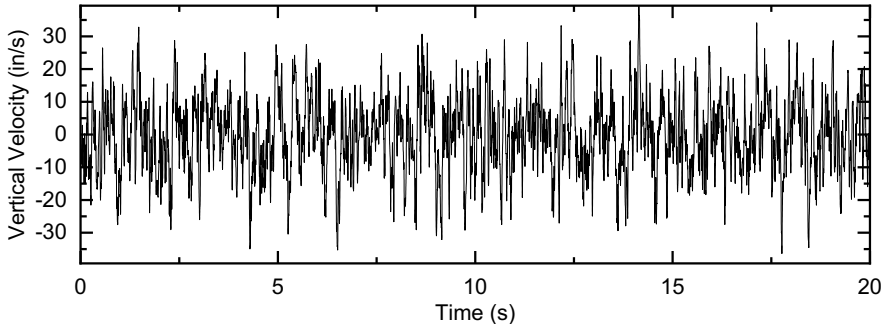
IRI-Acceleration Correlations

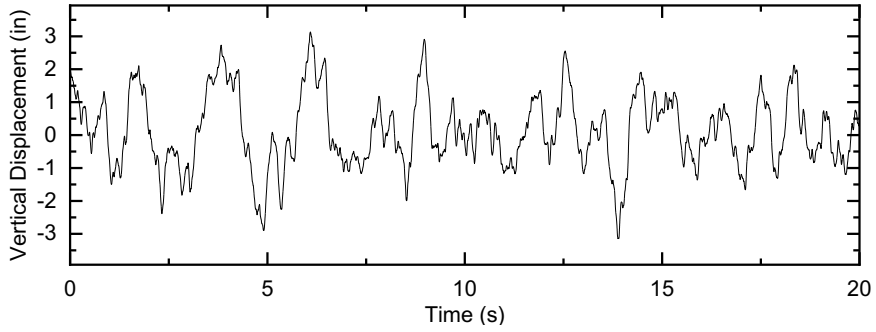


Simulated Vehicle Responses

- **Full-car model predicts vehicle responses based on road-roughness level, driving speed, and vehicle's dynamic properties**

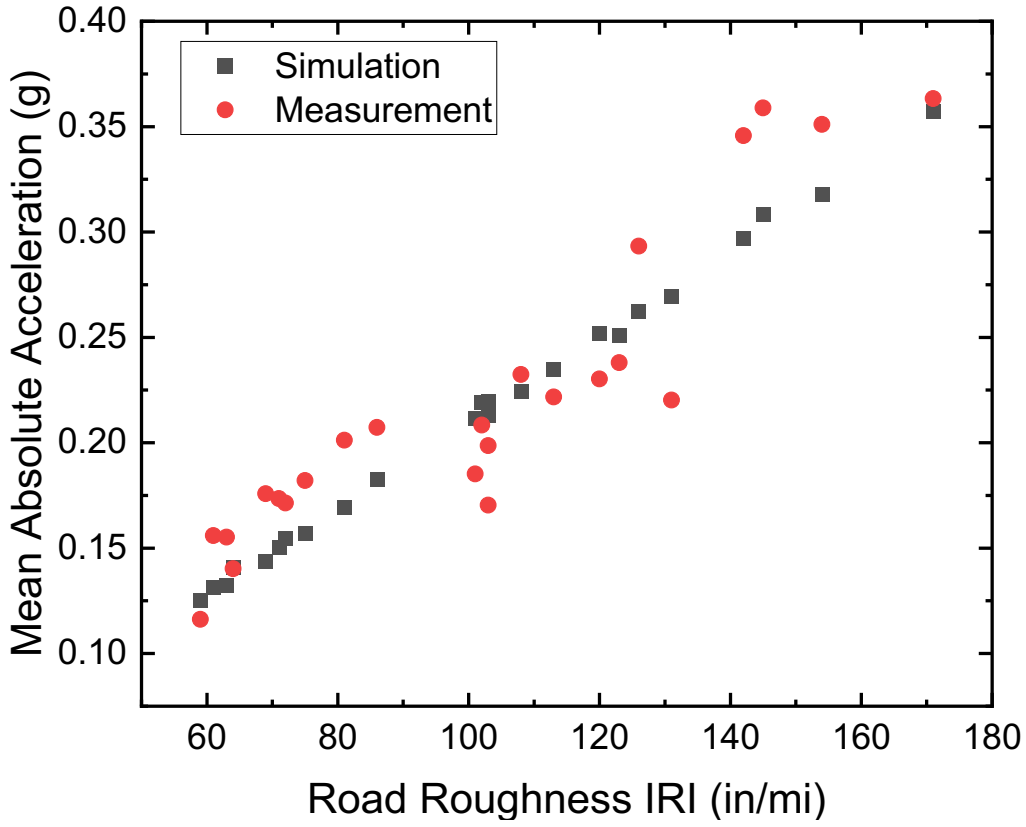






Correlation of Full-Car Model and Field Data

- The correlation coefficient between simulation and field measured data is 0.922
- Good agreement between field measurements and vehicle dynamic simulations.



Conclusions

- Vibration data collected from vehicle-mounted sensors could be a proper representation of actual pavement responses.
- The recently developed full-car model by Al-Qadi and coworkers has been successfully used to validate the field data.
- Results show that the integration, of vehicle-mounted sensor measurements and the newly developed full-car model, could successfully predict pavement roughness.

Acknowledgement

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Q&A