

V-PI in LCA

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100
1908 - 2008



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Should indirect pavement environmental impacts

(such as vehicle-pavement interaction as a function of road profile and environmental impacts through goods damage and vehicle life span reduction)

be considered in the LCA system for pavement or not?

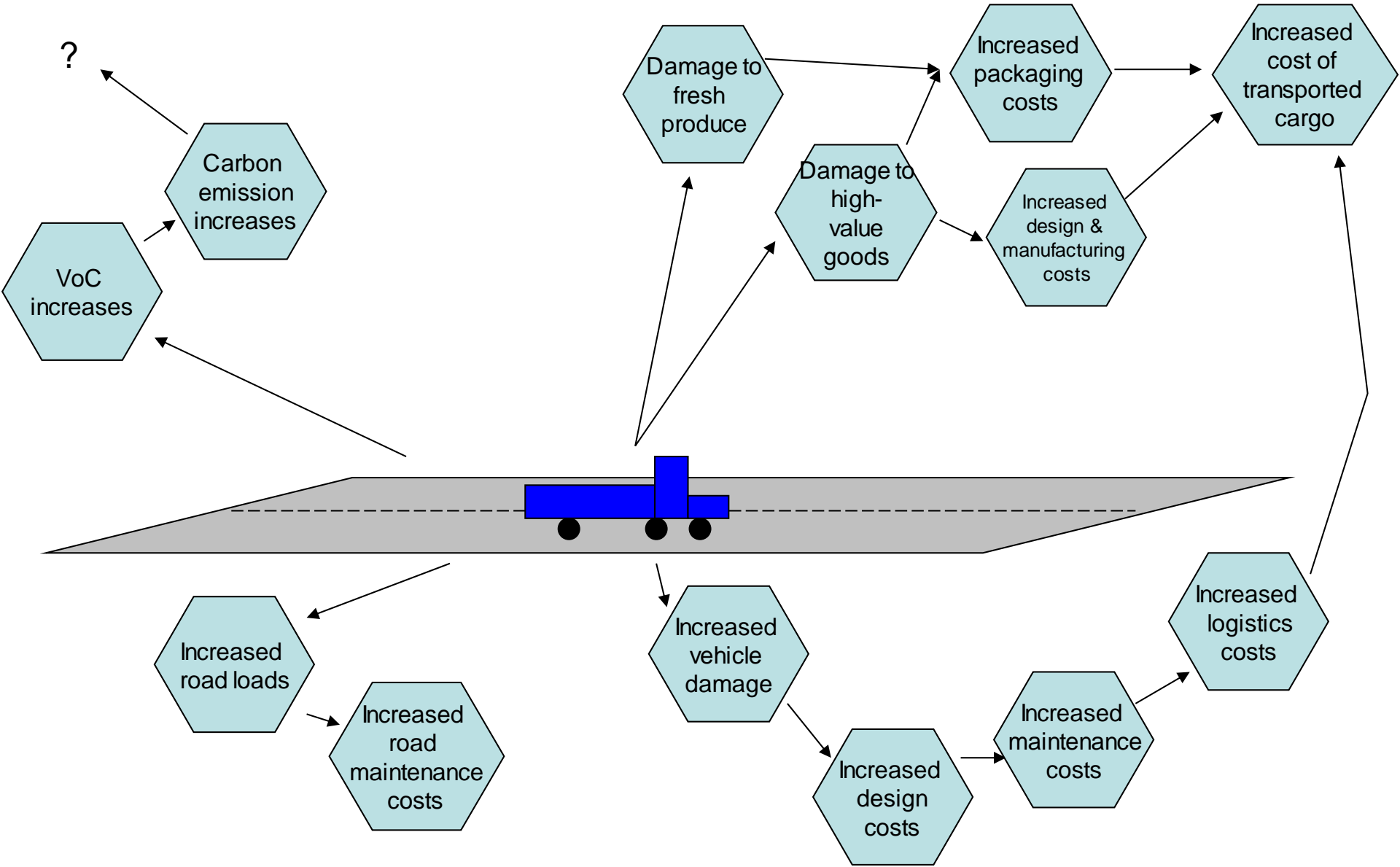
Content

- $V\text{-PI} = f(\text{road profile and other factors})$
- Transported cargo goods damage = $f(\text{road profile, and other factors})$
- Vehicle life span = $f(\text{road profile and other factors})$
- LCA attempts to evaluate cradle to grave
- **Therefore** - Should these indirect pavement environmental impacts be considered in LCA system for pavement or not?

Definition of V-PI

- Method in which vehicle properties and operational conditions are affected by road profile
- Traditionally attempted to evaluate dynamic loads on pavement
- Many more factors affected

Potential effects of deteriorating riding quality.



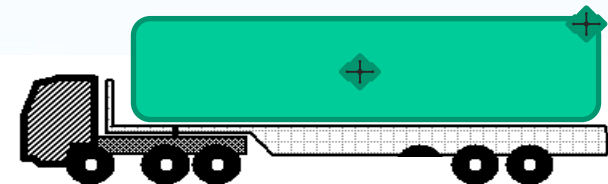
Parameters affecting V-PI

- Vehicle dimensions and type
- Components (tires, suspension, etc)
- Operational conditions (speed, load)
- **Pavement profile**

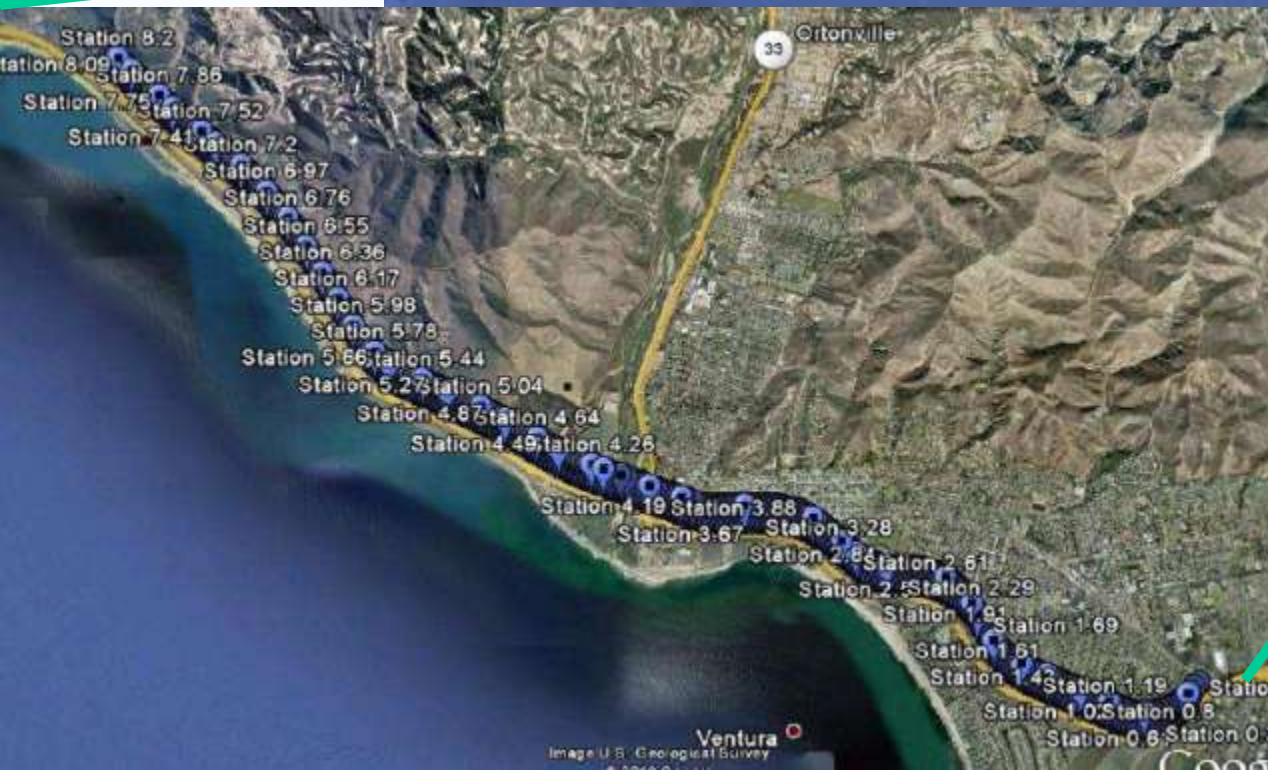
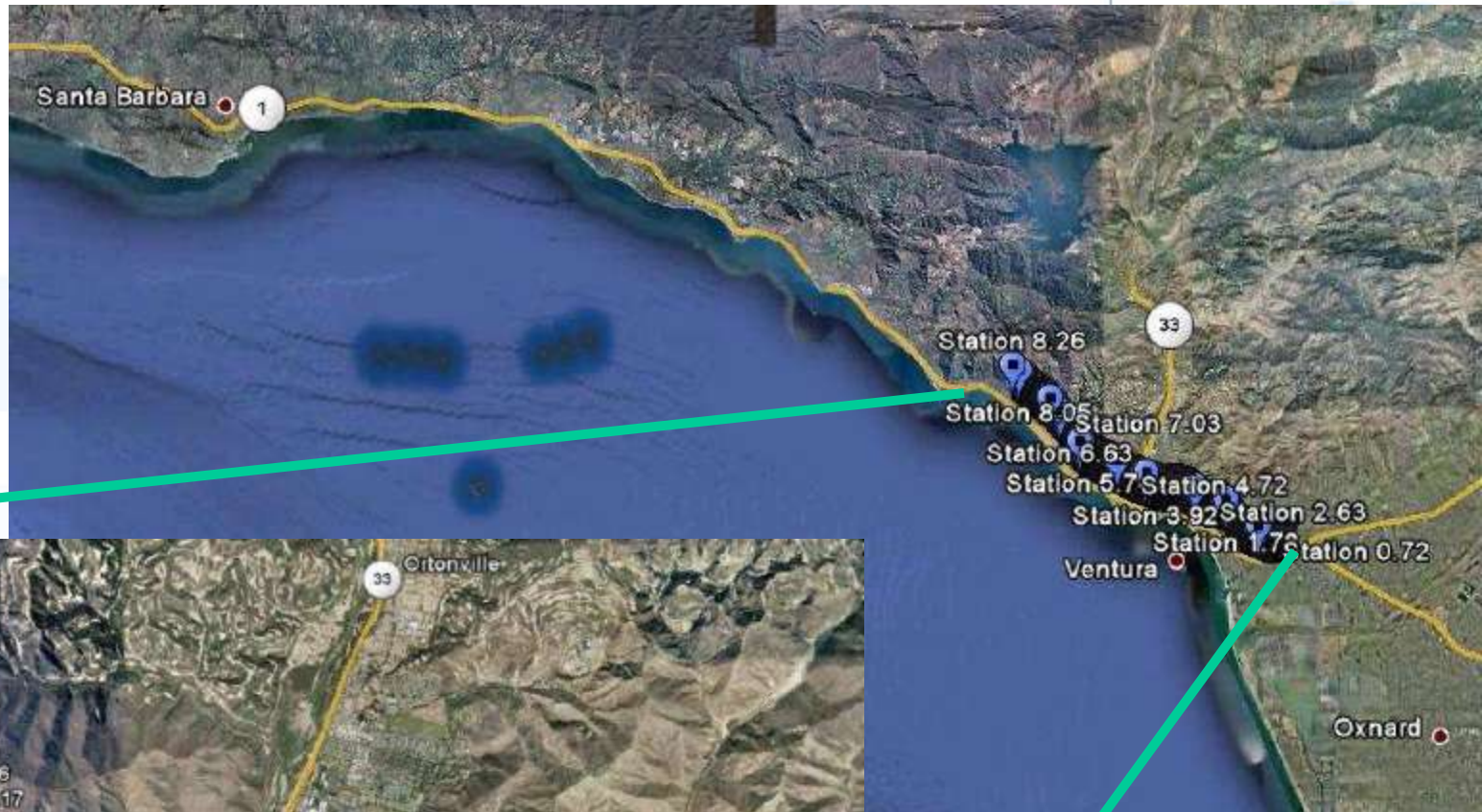
- **General outcomes** (only highlights)
 - Average loads remain constant, Standard Deviation affected
 - Speed
 - higher speed, more variation
 - Load
 - higher load, less variation (but at higher average)
 - Pavement profile
 - higher roughness, more variation

Issues focused on for this presentation

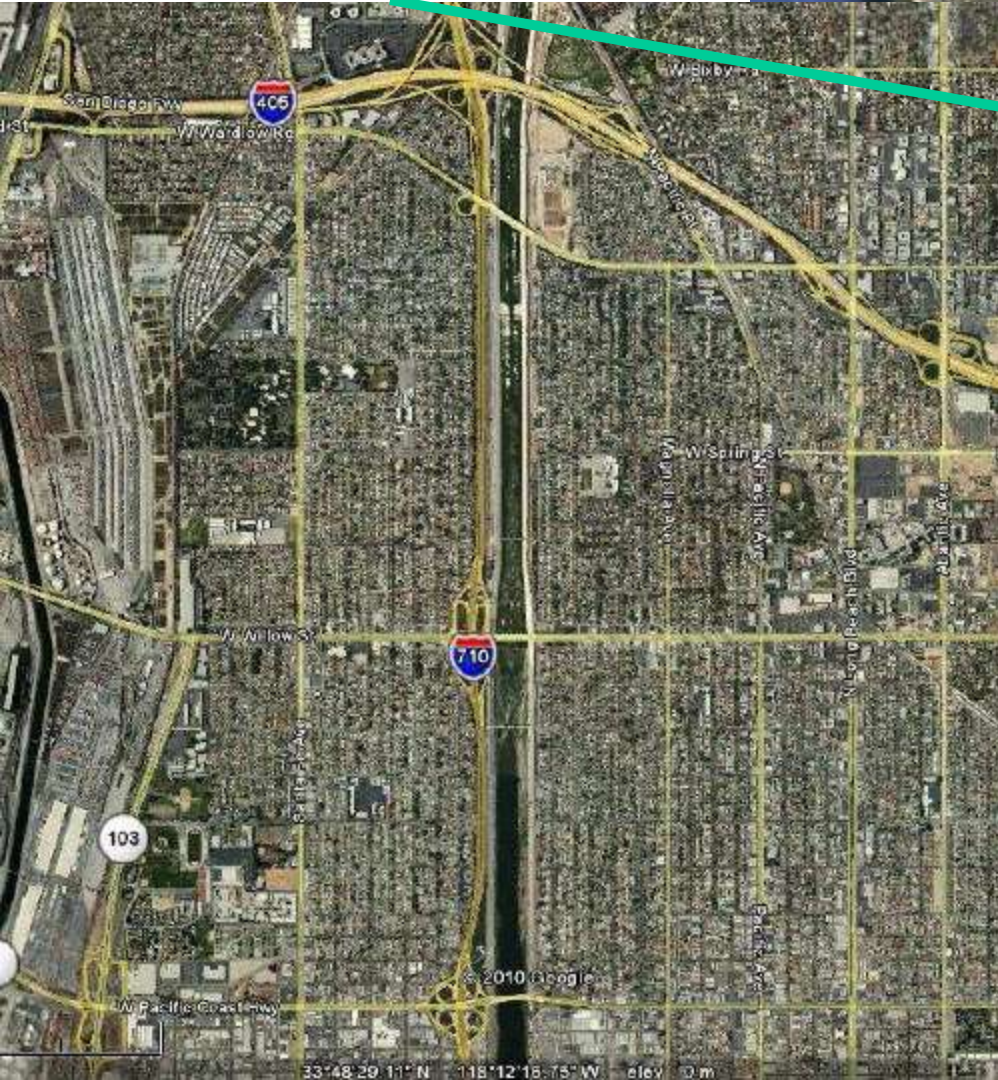
- Tire loads applied to the pavement
- Fuel consumption and vehicle costs
- Cargo damage
- Based on 2 California pavement sections
 - US101
 - Ventura, Ca; 8 miles (13 km)
 - US710
 - nbl – (North bound lane) 2.7 miles (4.4 km)
 - sbl – (South bound lane) 2.7 miles (4.4 km)
 - 5-axle articulated truck (3S-2)



US101 location



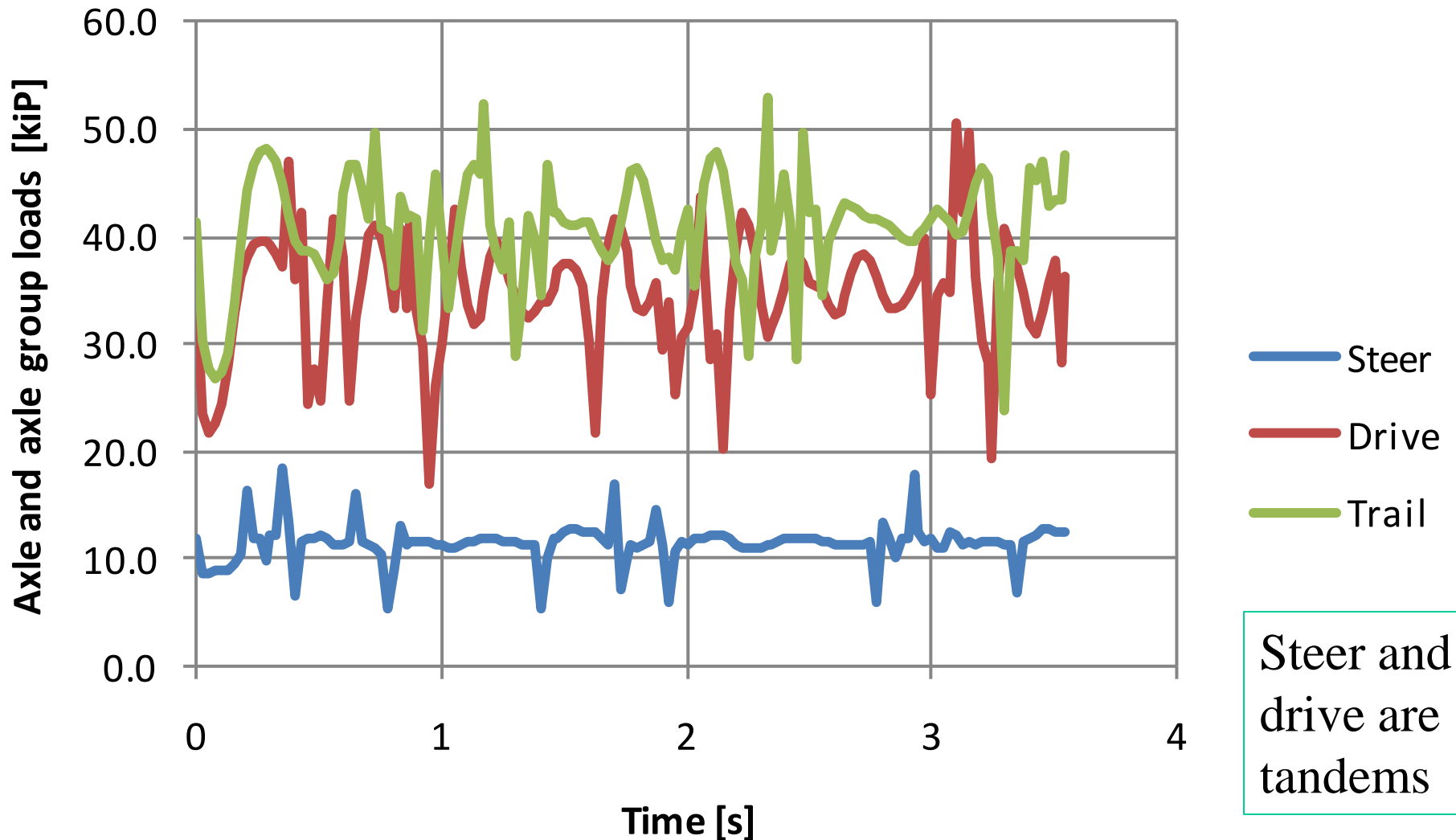
US710 location



Outputs affected by V-PI

- Tire loads applied to the pavement
- Example from UC analyses

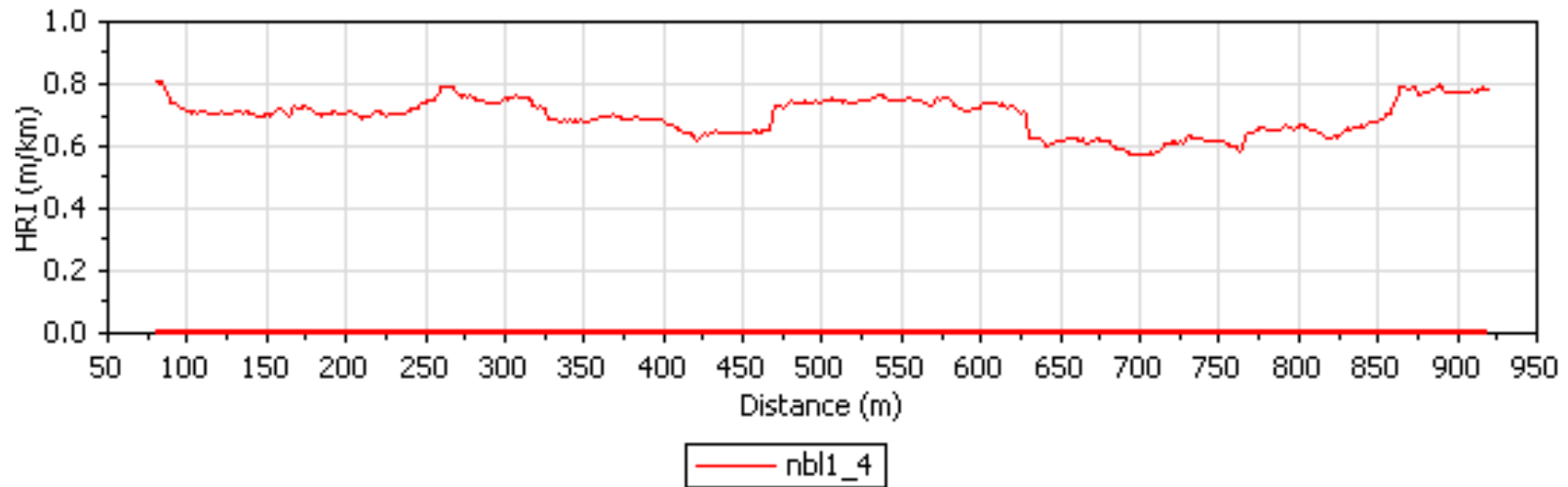
Analyses – Description of data – Time vs steer load 62.5 m/h, full, 131 HRI (Run498) (only 3.6 s shown) US101



US710 nbl1_4 - 46 Average HRI

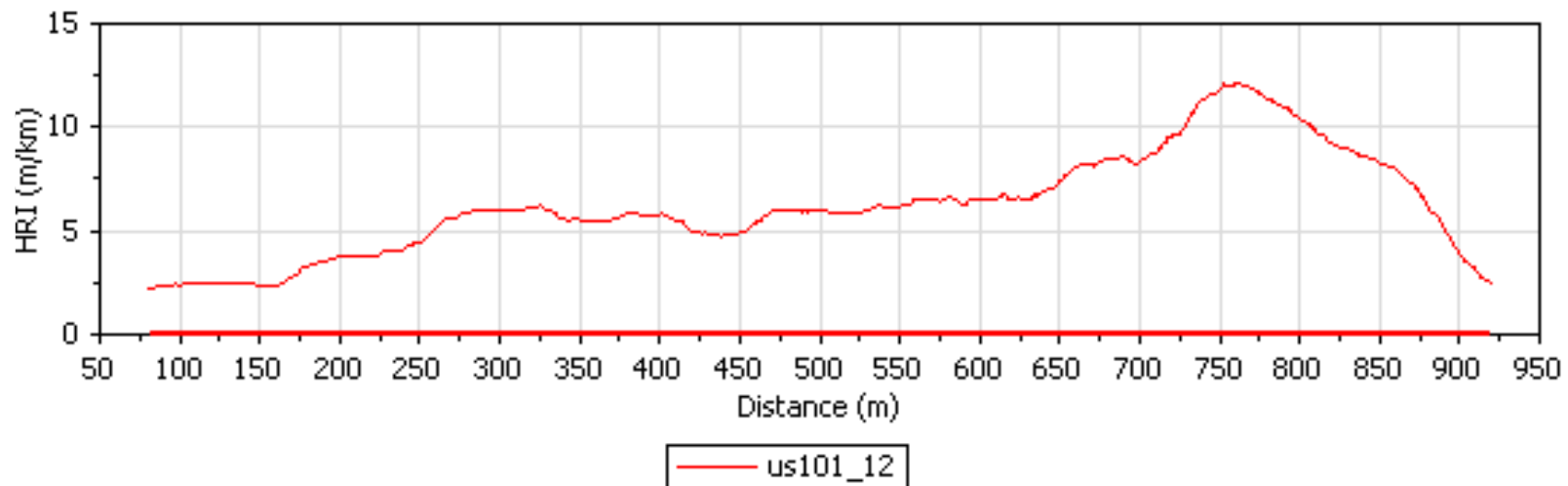
US101_12 - 356 Average HRI

HRI 46



Note different y-scales and metric units

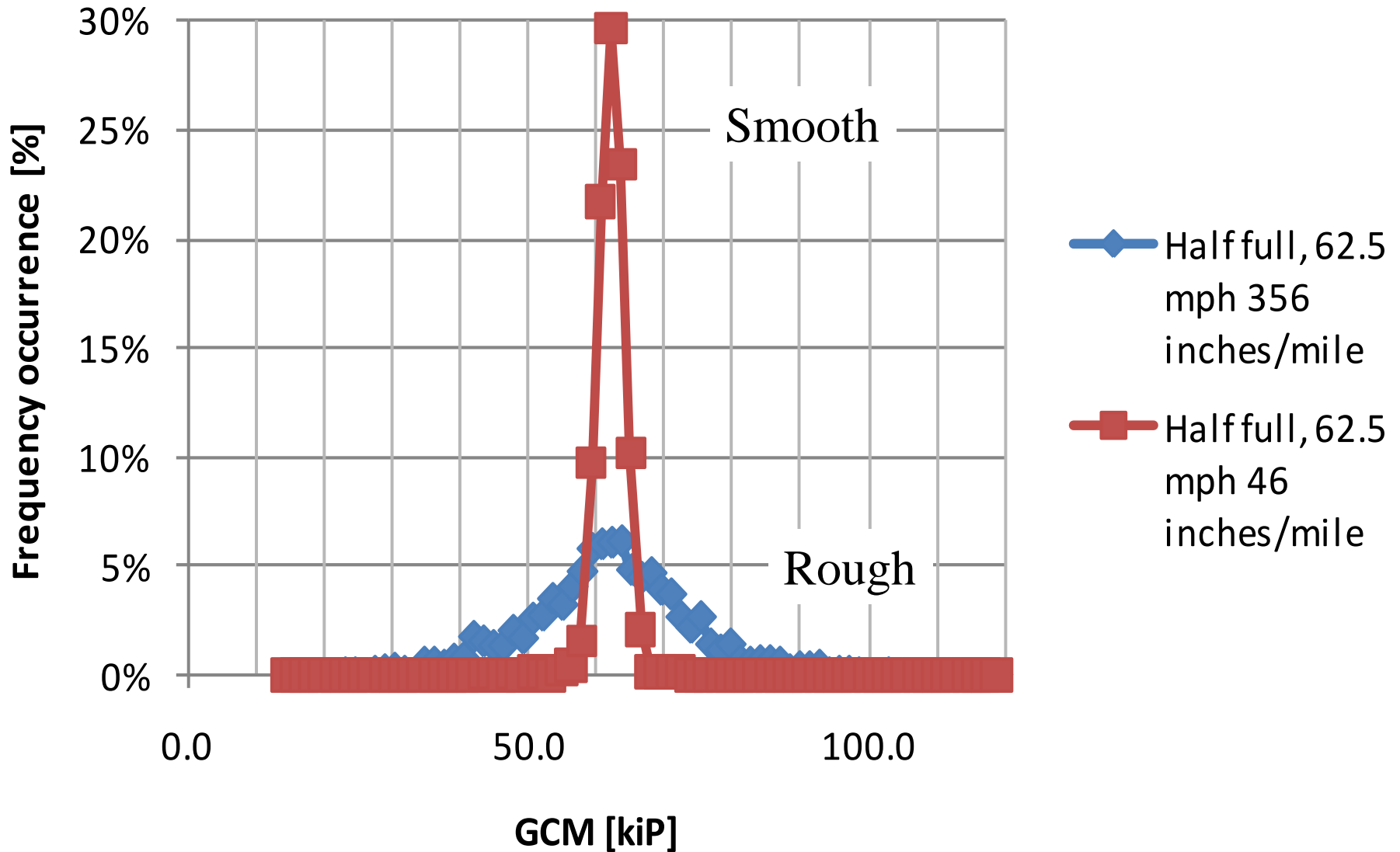
HRI 356



Histograms of data

nbl1_4 (smoothest) vs US101_12 (roughest)

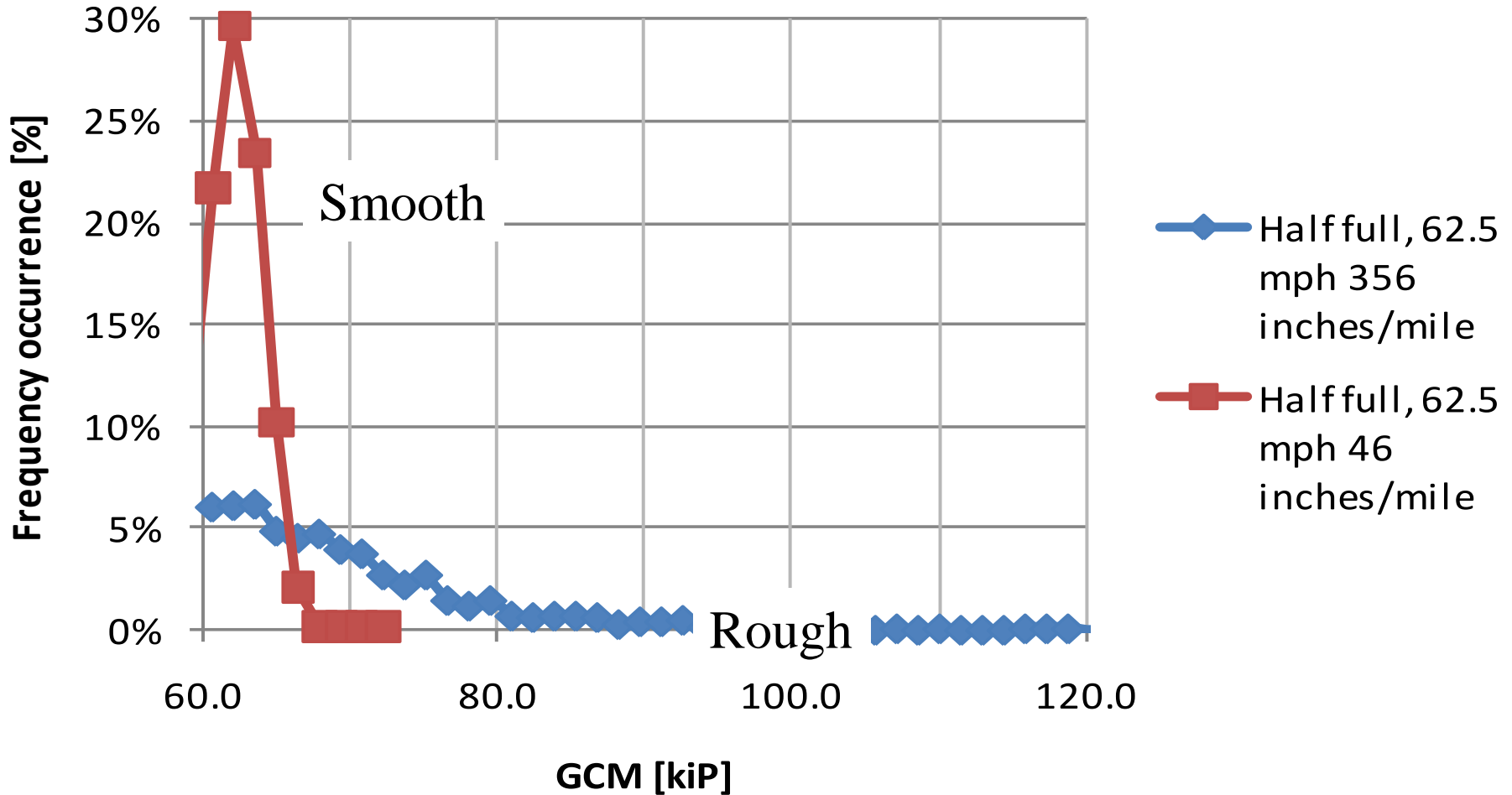
Half full, 62.5 mph



Histograms of data

nbl1_4 (smoothest) vs US101_12 (roughest)

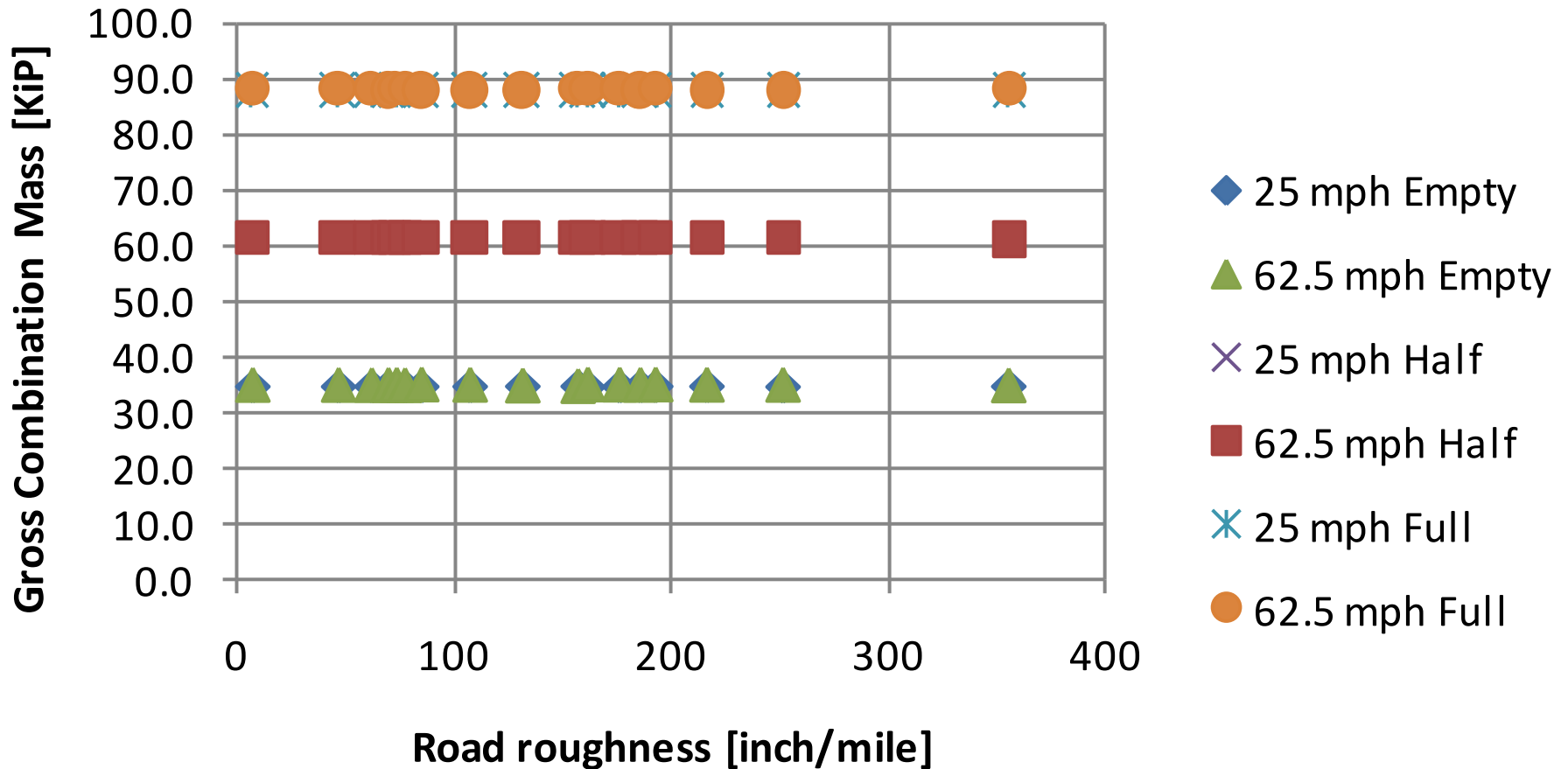
Half full, 62.5 mph (**Enhanced x scale**)



Relative damage [ESALs]						
1.2	2.0	3.3	5.0	7.3	10.3	14.1

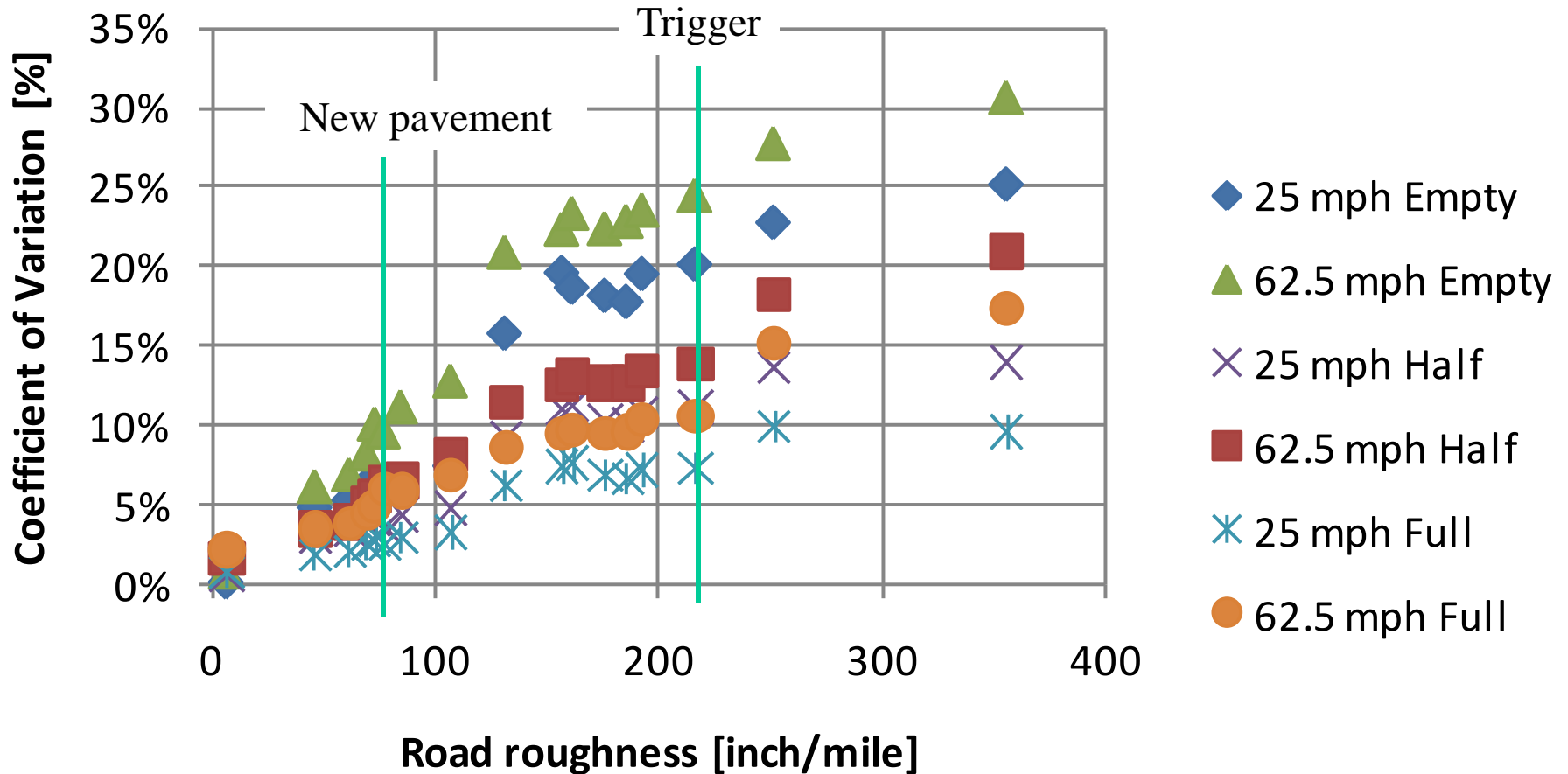
HRI vs LOAD (individual speeds)

Average of loads



HRI vs LOAD (individual speeds)

Coefficient of Variation of Loads

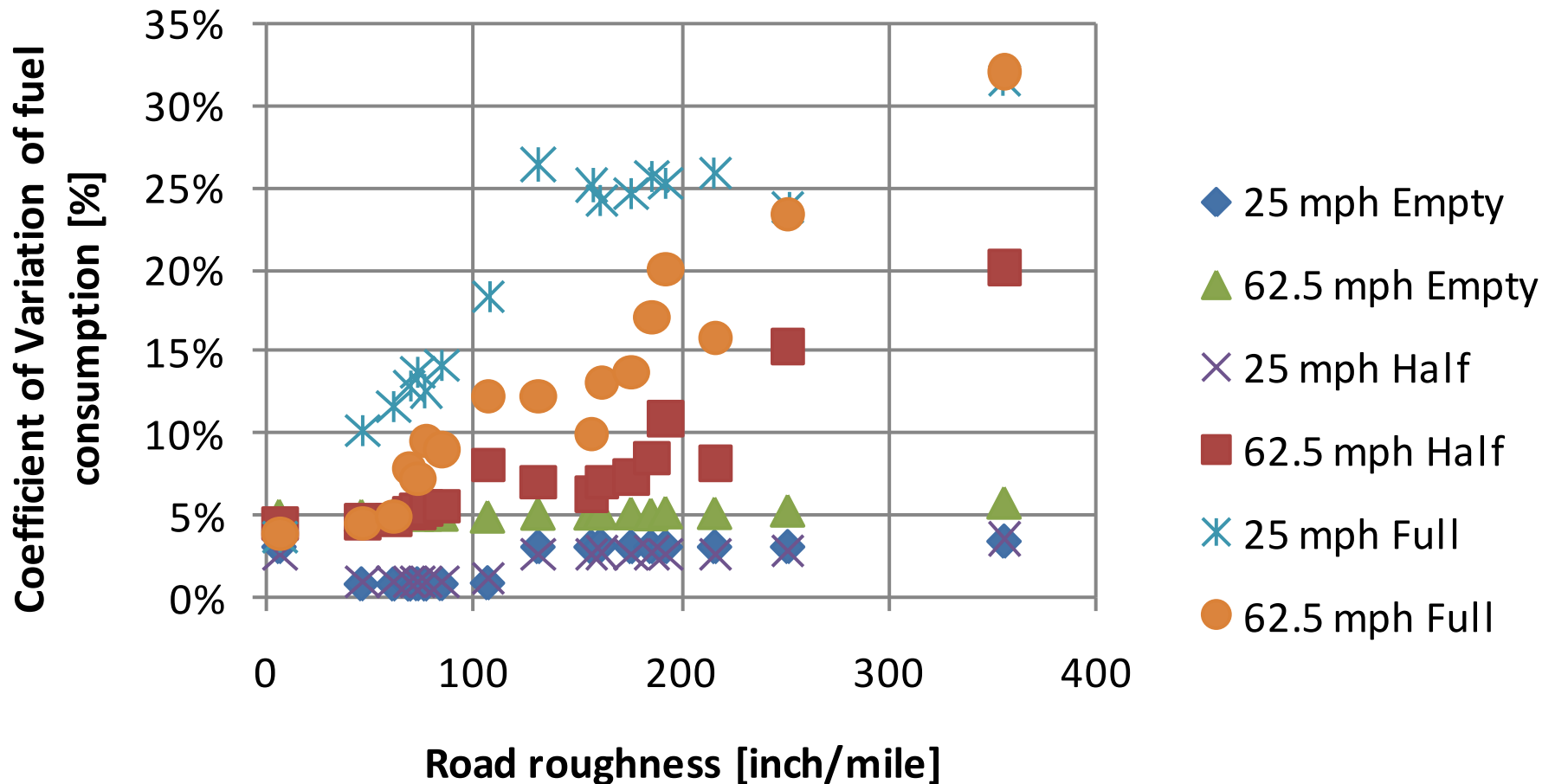


Outputs affected by V-PI

- Fuel consumption and vehicle costs
- Example from UC analyses

HRI vs FUEL CONSUMPTION (individual speeds)

Coefficient of Variation of fuel consumption

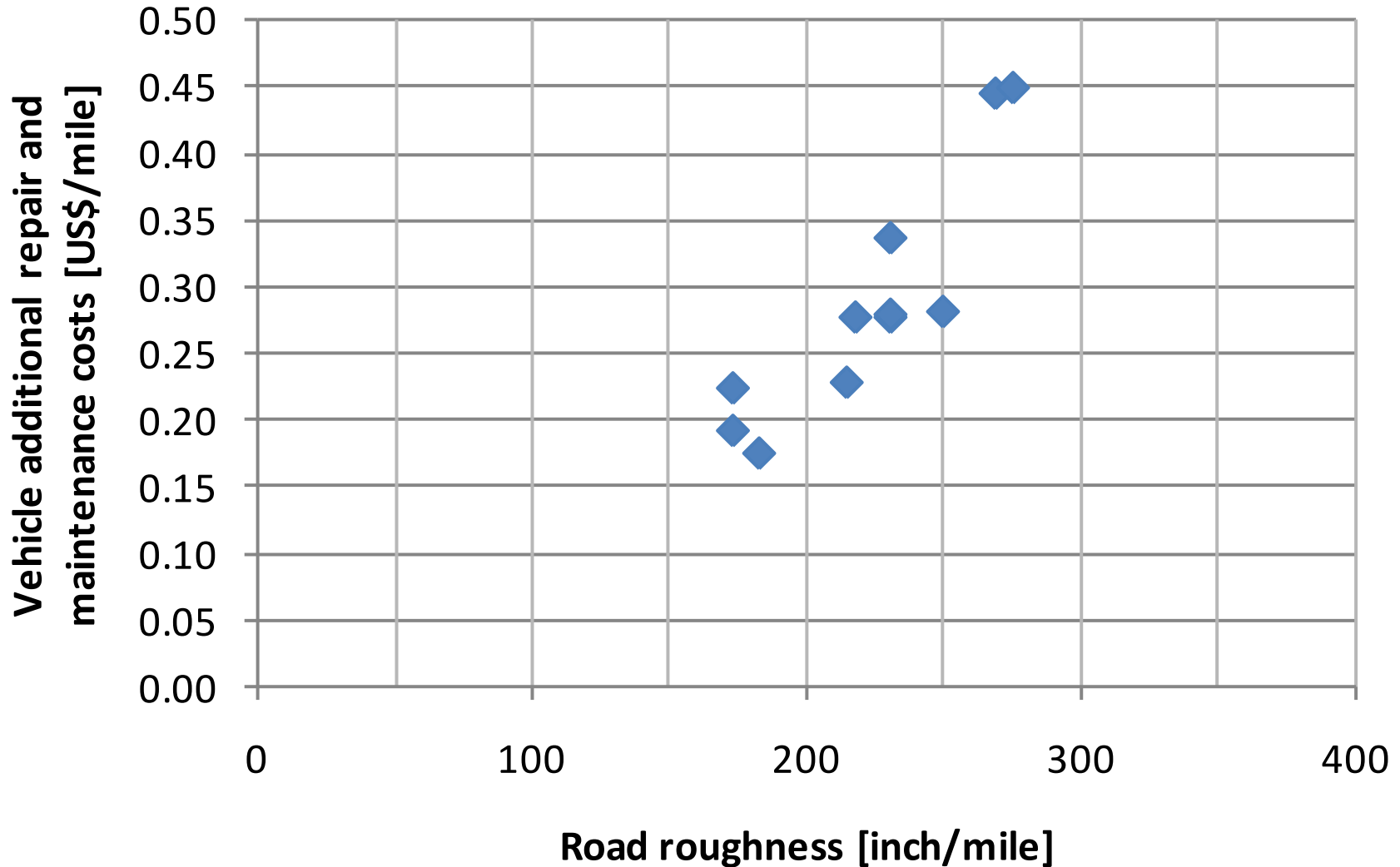


Outputs affected by V-PI

- Imperial example
- Cargo damage
- Davis fruit examples
- Accelerations from UC analyses

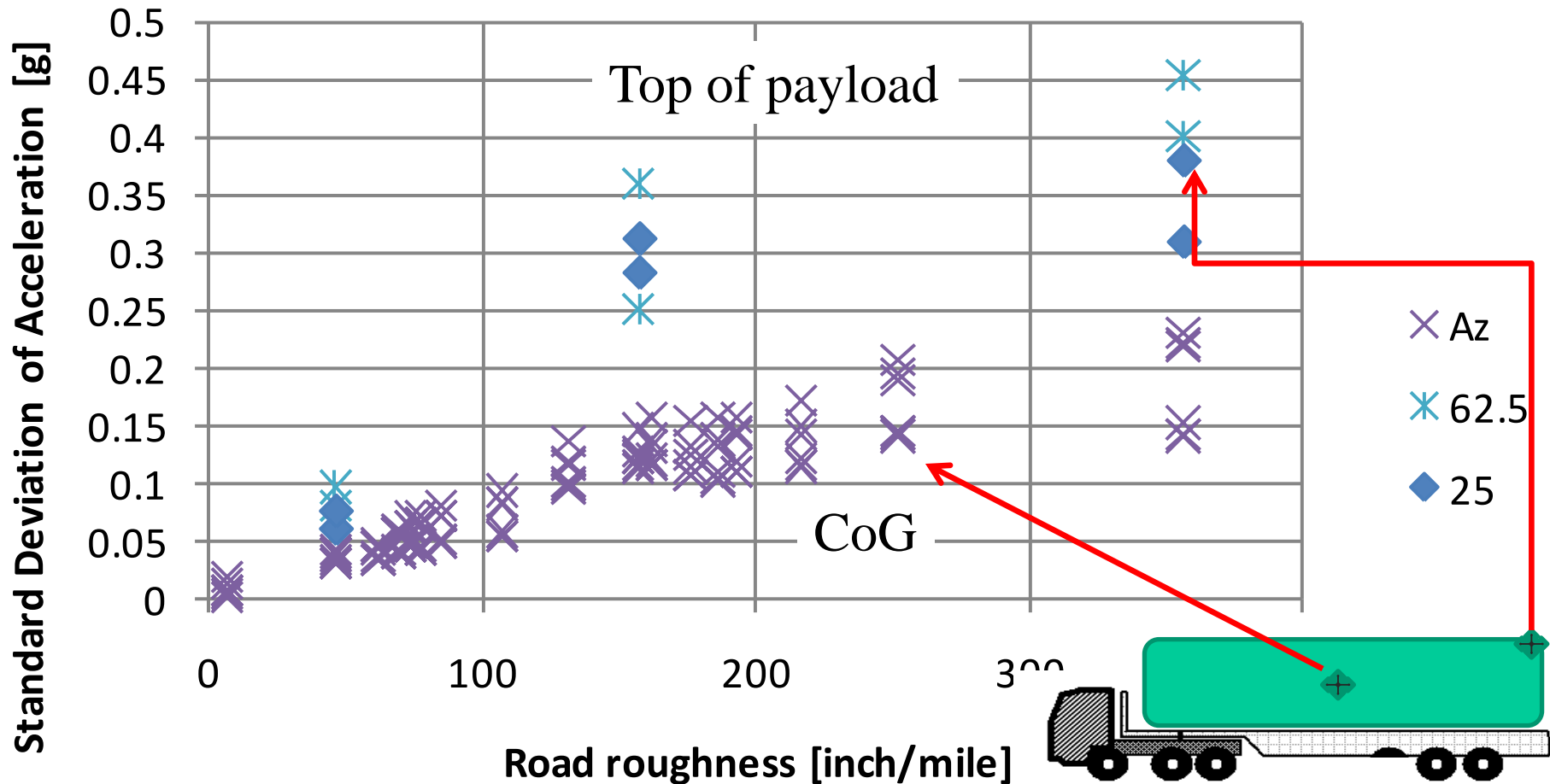
Actual data from SA State of Logistics survey

560 trucks, dedicated routes



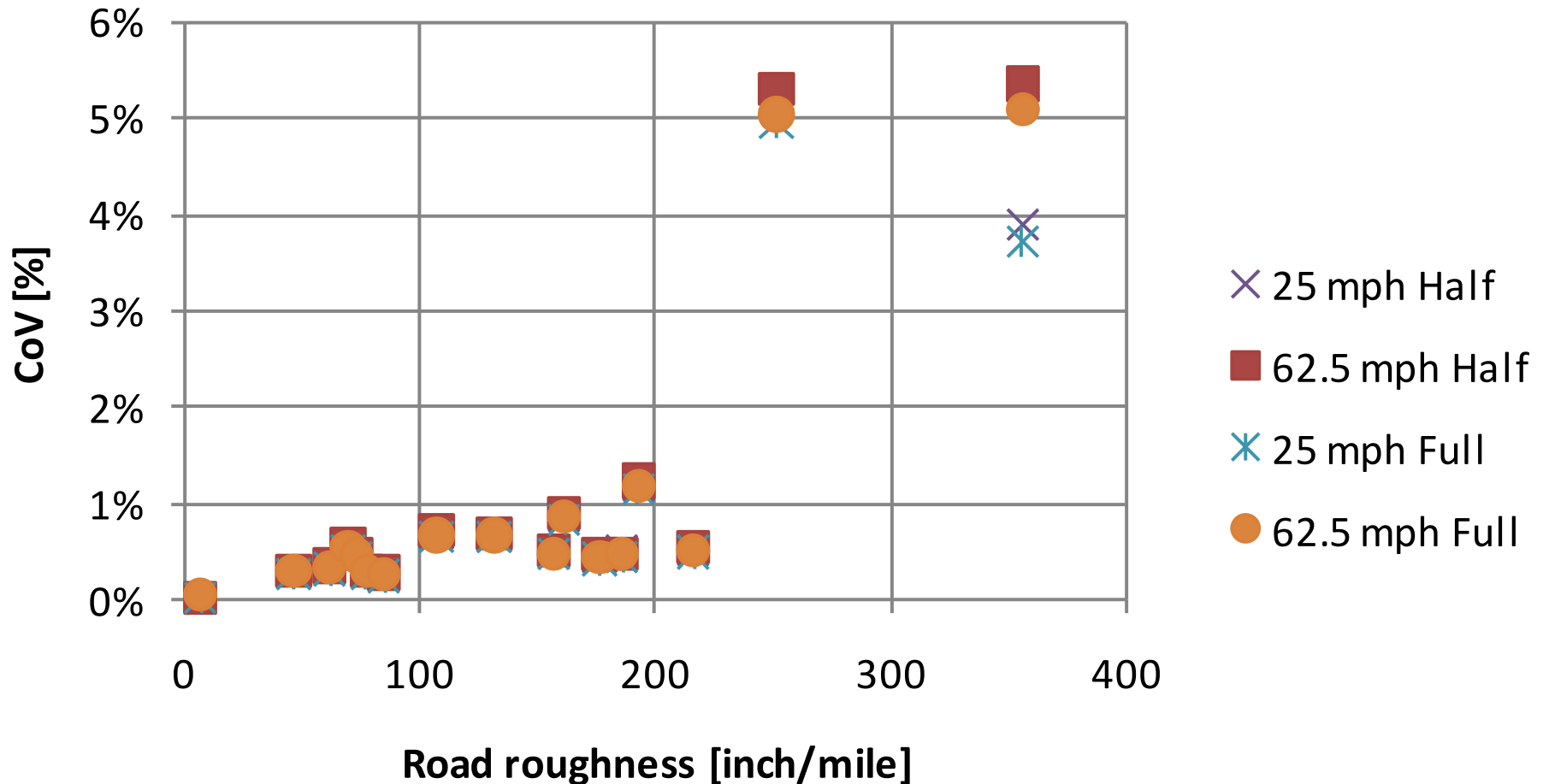
HRI vs CENTER OF GRAVITY and TOP FAR BEHIND VERTICAL ACCELERATION (individual speeds)

STDev Acceleration CoG and Top back of Payload (Az)



HRI vs CoV of HEIGHT OF CENTER OF GRAVITY (individual speeds)

CoV Height of Centre of Gravity Payload (ZCG)



So what

- What are the implications for LCA?
- Pavement
 - Increased “overloads”
- Vehicles
 - Increased energy requirements
 - Increased vehicle damage
- Cargo
 - Increased cargo damage
- Broader economy
 - Increased pavement and vehicle damage, increased produce / goods damage and environmental impacts
- **Is it enough to warrant inclusion into LCA?**

So what

- What are the implications for LCA?
- State of Logistics analysis
- Who pays for damaged goods?
- Competitiveness
- Environmental impact – manufacturing energy and resources lost due to damage to produce / cargo
- **Is it enough to warrant inclusion into LCA?**