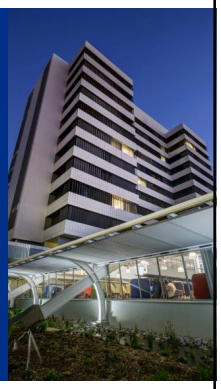
# SARF
# RIDING QUALITY
# COURSE



5 November 2015

## Contents


- 8:00 to 9:00
  Introduction to road riding quality
  Definitions and concepts involved in riding quality
- 9:00 to 10:00
  Measuring riding quality
- 10:30 to 12:30
  Analysing riding quality data
- 13:30 to 15:00
  Interpreting riding quality data
  Riding quality and Vehicle-Pavement Interaction
- **15:30 to 16:30**
  **Effects of riding quality on road users and costs**




## Effects of riding quality on road users and costs



- SOL analysis
- Caltrans analysis

## State of Logistics analysis

- Effect on vehicle maintenance
- BC analysis
- Effects on freight
- www.csir.co.za/sol



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## Vehicle maintenance

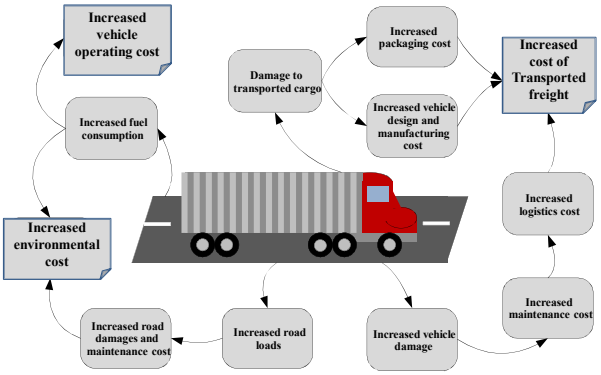
- Limited case study - investigate potential effect that bad road surfaces could have on vehicle damages and costs
- Anecdotal evidence - fleet of 577 similar trucks
- Subjective classification of road condition
- Analysis indicated that
  - trucks traveling on roads with worse riding conditions experien cent and
  - mainly du trailer co

*Table 6: Potential increase in vehicle damage costs under deteriorating road conditions*

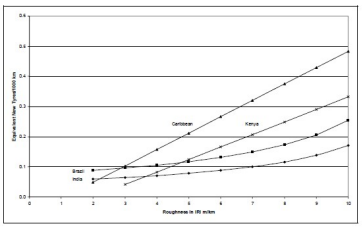
| Road condition | % Total vehicle damages | % Total costs of vehicle damages | % Increase in costs |
|---|---|---|---|
| 2 - Good | 5,2% | 3,9% | |
| 3 - Average | 17,4% | 30,8% | 684% |
| 4 - Bad | 77,4% | 65,2% | 1 560% |



### Vehicle maintenance



## HDMIV - tyres




:ffect of Roughness on Passenger Car Tyre Consumption

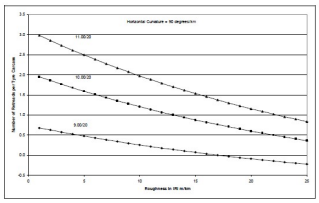



Figure B5.6: Effect of Roughness on Number of Retreads

Tyre life = 166.47 -31.83 ln (13 * IRI)

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## HDMIV speed

Table B2.7: Effect of Roughness on Passenger Car Speeds from User Cost Studies

| Country | Reference | Decrease in Speed (km/h) per Increase in IRI m/km |
|---|---|---|
| Brazil | GEIPOT (1982) | 2.00 |
| Caribbean | Morosiuk and Abeynayaka (1982) | 0.62 |
| India | CRRI (1982) | 2.57 |
| Kenya | Watanatada (1981) | 0.64 |

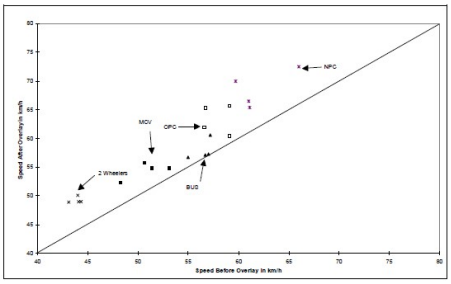


Figure B2.9: Effect of Roughness Reductions on Speed

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## HDMIV maintenance and repair costs

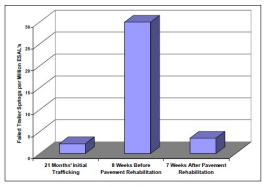


Figure B6.5: Effect of Rehabilitation on Trailer Spring Failure

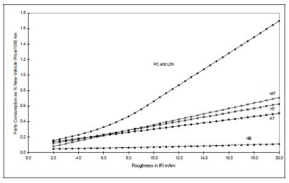


Figure B6.2: Effect of Roughness on HDM-III Parts Consumption

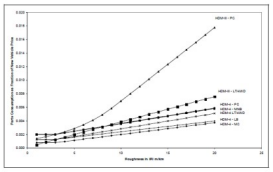

Figure B6.9: Comparison of HDM-4 and HDM-III Parts Consumption: Light Vehicles

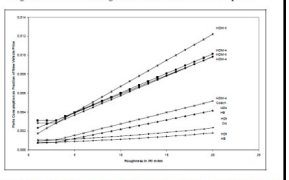

Figure B6.10: Comparison of HDM-4 and HDM-III Parts Consumption: Heavy Vehicles

## HDMIV maintenance and repair costs

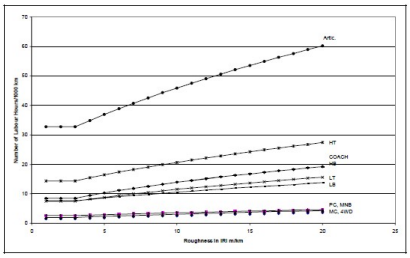


Figure B6.11: HDM-4 Labour Hours Predictions

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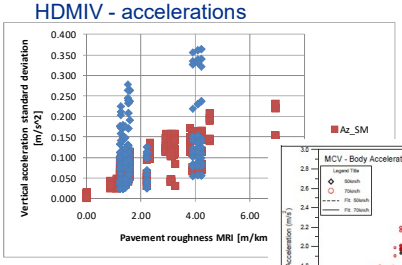
## HDMIV - accelerations



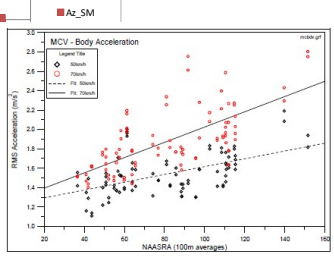




Figure B6.6 Effect of Roughness on Body Acceleration



## HDMIV depreciation costs

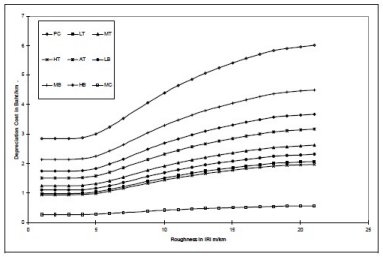



Figure B8.4: Example of the Effect of Roughness on Depreciation Costs

An example of the depreciation predictions using the optimal life method is given in Figure B8.4. This was calculated using data for nine vehicle classes with unit cost data from Thailand and the function of lifetime utilisation versus roughness given earlier in Figure B7.10.



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# Benefit-Cost analysis

- Annual road maintenance cost derived from actual rc 2006 on Gaut
- Vehicle maint including fuel
- Total potentia determined

Table 2: Summary of vehicle maintenance and repair costs for routes with different IRIs

| Company | Route information | Average IRI (m/km) | Road condition rating | Average maintenance and repair costs (R/km) |
|---|---|---|---|---|
| A | Gauteng to Durban (N3) | 2,7 | Good | 1,01 |
| | Gauteng to Cape Town (N1) | 3,6 | Fair | 1,30 |
| B | Gauteng to Durban (N3) | 2,7 | Good | 0,90 |
| | Gauteng to Nelspruit (N4) | 2,9 | Fair | 0,82 |
| | Gauteng to Witbank (N12) | 3,4 | Fair | 1,27 |
| | Gauteng to Rustenburg (N4) | 3,3 | Fair | 1,04 |
| | Gauteng to Richardsbay (N17 and N2) | 3,6 | Fair | 1,31 |
| | Johannesburg to Vereeniging (R82) | 3,6 | Fair | 1,57 |
| | Gauteng to Cape Town (N12 and N1) | 3,6 | Fair | 1,29 |
| | Gauteng to Botswana (N4) | 3,9 | Fair | 1,35 |
| | Newcastle to Gauteng (N11 and N17) | 4,2 | Bad | 2,09 |
| | Gauteng to construction sites | 4,3 | Bad | 2,13 |



## Benefit-Cost analysis

Table 7: Potential savings in vehicle operating costs

| Year | Total vehicle operating costs (R/km) | Potential savings (R/km/vehicle) | Traffic volumes | | Potential savings | |
|---|---|---|---|---|---|---|
| | | | Minimum | Maximum | Minimum | Maximum |
| 0 | 3.00 | – | 536 550 | 992 070 | – | – |
| 1 | 3.50 | 0.50 | 563 378 | 1 041 674 | 281 689 | 520 837 |
| 2 | 3.80 | 0.80 | 591 546 | 1 093 757 | 473 237 | 875 006 |
| 3 | 4.10 | 1.10 | 621 124 | 1 148 445 | 683 236 | 1 263 290 |
| 4 | 4.60 | 1.60 | 652 180 | 1 205 867 | 1 043 488 | 1 929 388 |
| 5 | 5.20 | 2.20 | 684 789 | 1 266 161 | 1 506 536 | 2 785 553 |
| 6 | 6.00 | 3.00 | 719 028 | 1 329 469 | 2 157 085 | 3 988 406 |
| 7 | 7.00 | 4.00 | 754 980 | 1 395 942 | 3 019 919 | 5 583 768 |

Table 8: Benefit-cost ratio of keeping a road in a good condition

| Year | Road maintenance costs (R/km) | Potential savings (R/km) | | Benefit-cost ratio | |
|---|---|---|---|---|---|
| | | Minimum | Maximum | Minimum | Maximum |
| 1 | 600 000 | (318 311) | (79 163) | | |
| 2 | 630 000 | (156 763) | 245 006 | | |
| 3 | 661 500 | 21 736 | 601 790 | | |
| 4 | 694 575 | 348 913 | 1 234 813 | | |
| 5 | 729 304 | 777 232 | 2 056 250 | | |
| 6 | 765 769 | 1 391 316 | 3 222 637 | | |
| 7 | 804 057 | 2 215 862 | 4 779 711 | | |
| | Total | 4 279 985 | 12 061 043 | 1.88 | 3.47 |

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## Freight effects

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## Freight effects

- Damage to freight due to road roughness

**Figure 16:** Typical damage experienced in fresh produce cargo due to road roughness

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## Freight effects

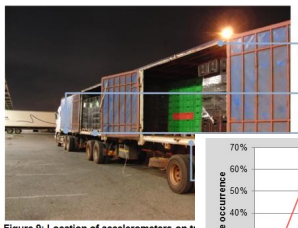


**Figure 9: Location of accelerometers on t**

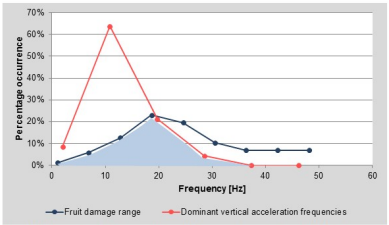


**Figure 10: Comparison between dominant frequencies experienced by fruit cargo and the vibration range of fruit that results in damage.**

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## Comparison between vehicle accelerations and fruit properties

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## Freight effects

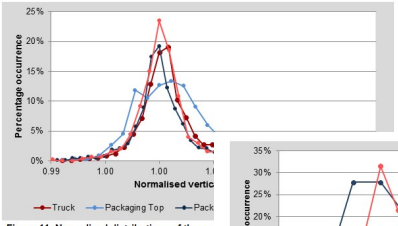


Figure 11: Normalised distributions of the ver
pallets at various packing levels

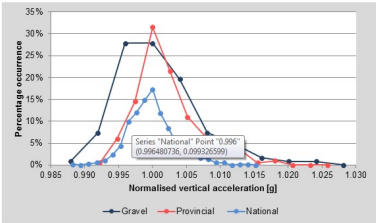


Figure 12: Normalised distributions of vertical acceleration experienced in the middle of the truck body for different road conditions.



## Freight effects

Table 6: Comparison of average wheat loss on good and bad roads.

| (a) Wheat loss by weight | | | | |
|---|---|---|---|---|
| Road condition rating | Load weight (tonne) | Loss per load (kg) | Loss/tonne loaded (kg/tonne) | Difference (kg/tonne) |
| Good | 34.71 | 36.09 | 1.04 | - |
| Bad | 22.86 | 37.85 | 1.66 | **0.62** |
| **(b) Wheat loss in Rand (Average values)** | | | | |
| Road condition rating | Wheat price (R/tonne) | Loss/tonne loaded (kg) | Value lost/tonne loaded (R) | Difference (R) |
| Good | R 2 167.82 | 1.04 | R 2.25 | - |
| Bad | R 2 167.82 | 1.66 | [illegible] | [illegible] |

# Caltrans analysis

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# Recent and current Caltrans analyses

- Evaluate the effects of riding quality on Caltrans network
- Focus on
  - direct effects
    - Vehicle costs and maintenance
    - Freight damage
    - Construction quality control
  - Indirect effects
    - Gross Domestic Product
    - Competitiveness



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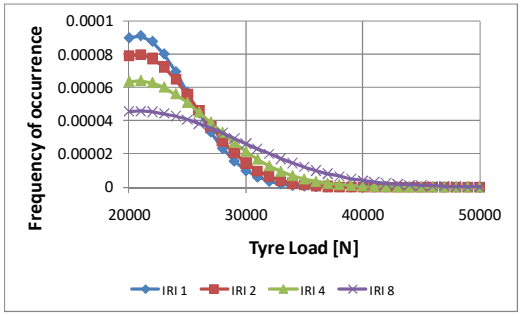
## Riding quality vs Tyre loads





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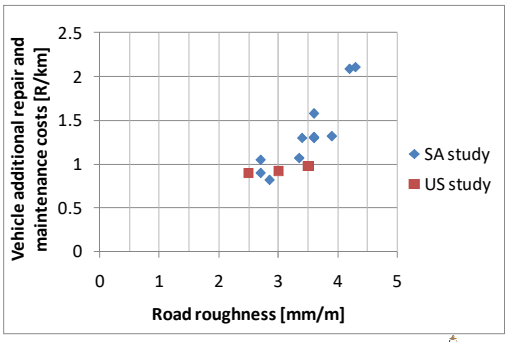
## Vehicle damage





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## Maintenance effects

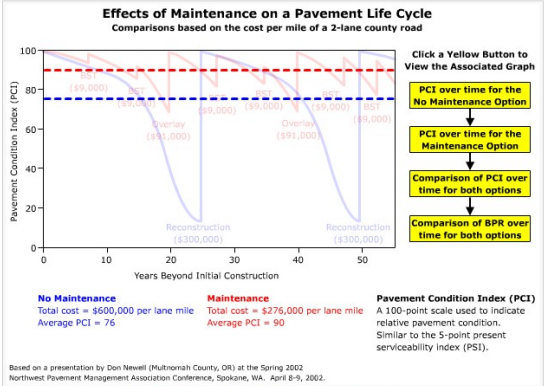


Figure 3: Effects of Maintenance on a Pavement Life-Cycle Interactive Picture

Challenges confronting road freight transport and the use of vehicle-pavement interaction analysis in addressing these challenges

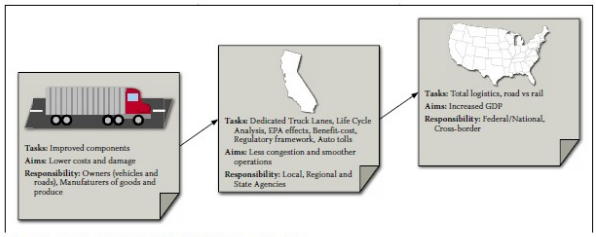


**Figure 2** Framework and Context for V-PI and Freight Damage and Logistics



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# Caltrans Agricultural



# Company A

- Agricultural company
- San Joaquin valley

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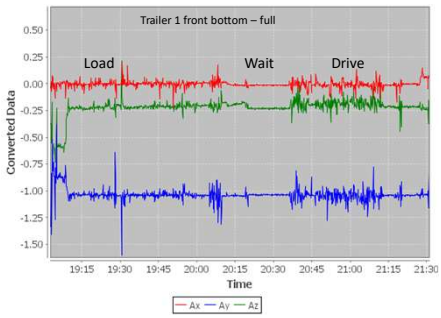
CA Legal Double
Type 11 (2S1-2)

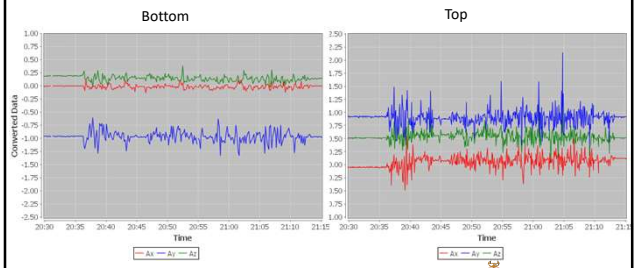
## Accelerometer installations

## Accelerometer - accelerations

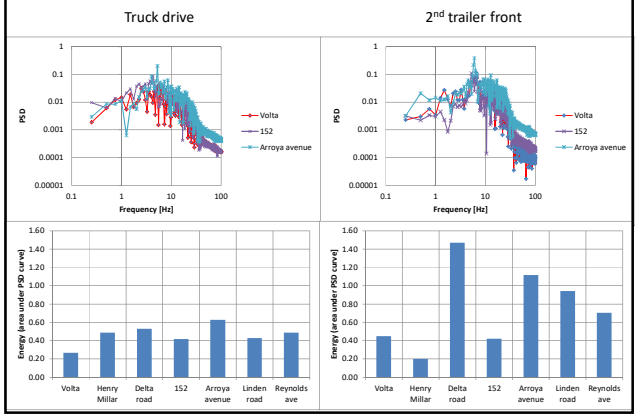
## Accelerometer - accelerations



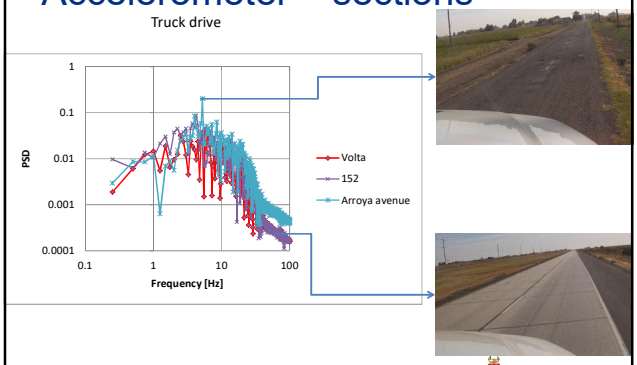

## Top vs bottom – 2nd trailer



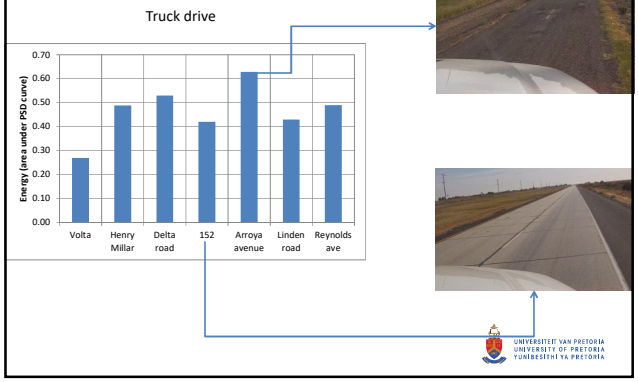

## Accelerometer – locations (empty)




## Accelerometer – sections



## Accelerometer – energy

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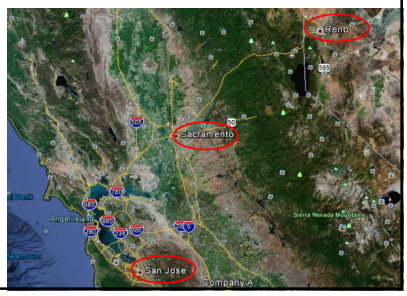
## Caltrans Highway



## Company B

- Freight movement
- Newark – Reno
- I80



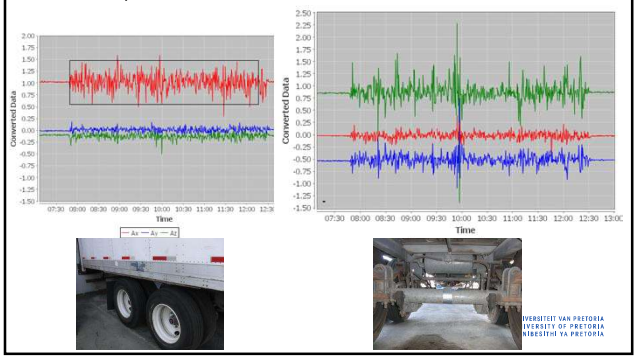

## Vehicle

STAA 48 feet (STAA Truck Tractor-Semitrailer)
FHWA Class 9

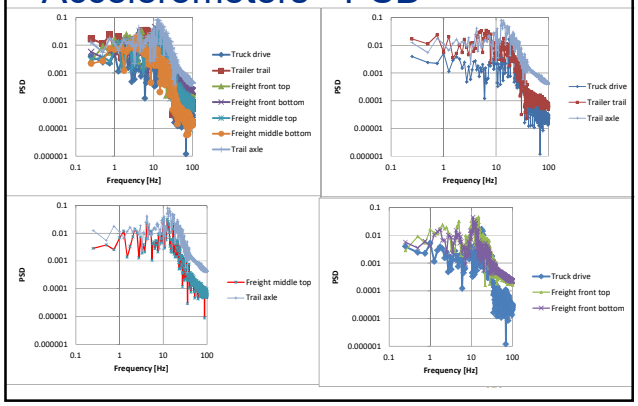
# Accelerometers - acceleration

Trailer body over back axle

On back axle

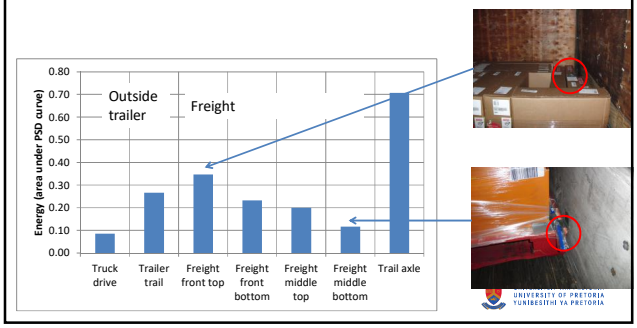



# Accelerometers - PSD

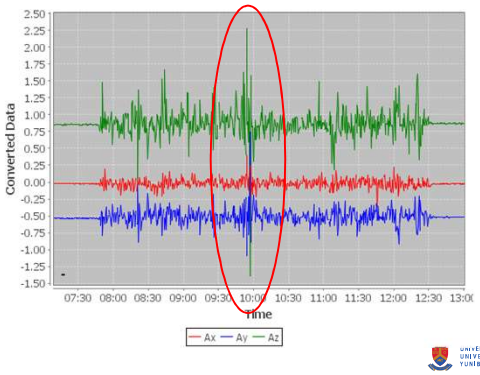



# Accelerometers - energy

Newark to Reno



# Full Reno to Newark trip

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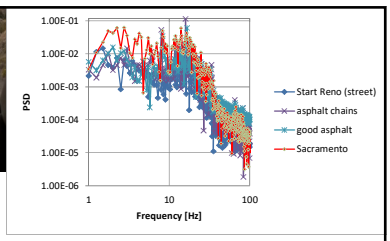
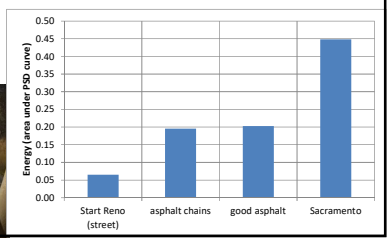
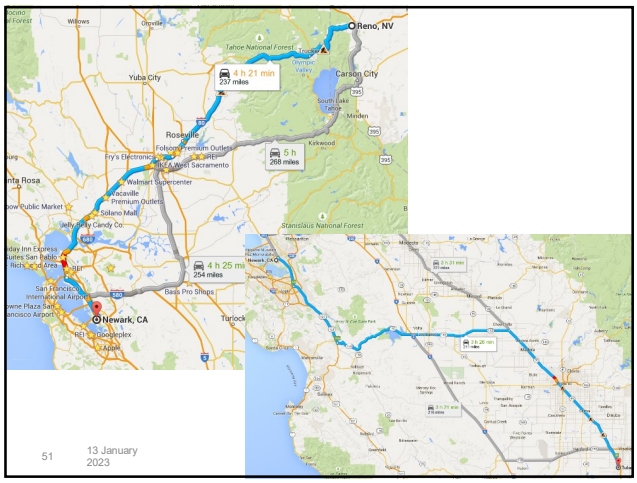
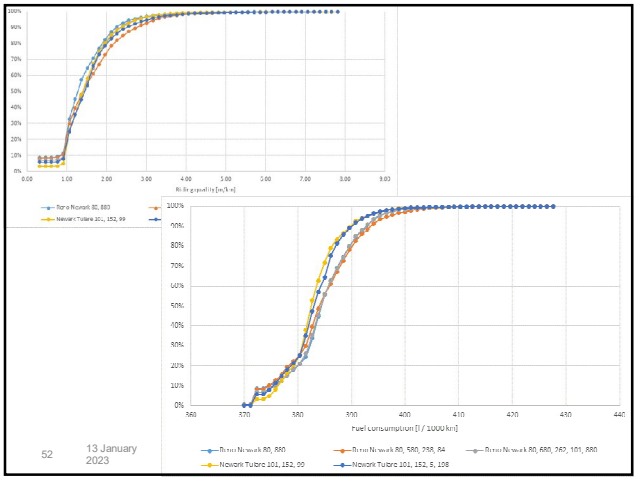
Freight front top





## Limpopo example

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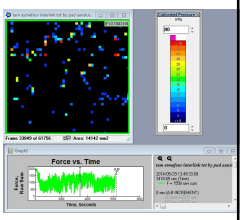
## Tomato and avocado contact stress

- Measured in situ during harvesting and trips
- Evaluated selected locations
- 10 Hz
- 1s selected for analyses



## Laboratory evaluation

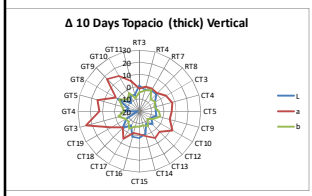
- Determine tomato and avocado stiffness (avocados later)
- Dependent on ripeness and direction and

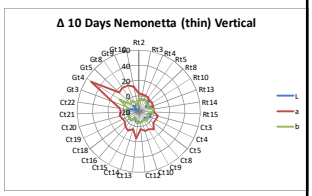
)th and 90th percentile σ from road

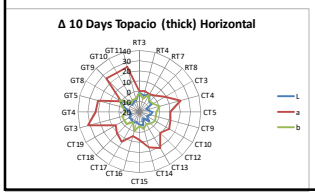
selected to

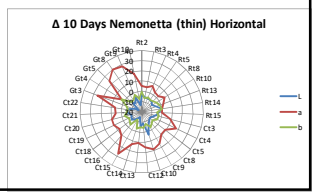
ough color

## Laboratory evaluation – change over time



**Summary**



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## So What?

- Importance
  - Indicator - blood pressure and fever
  - Infrastructure deterioration
  - Freight damage
  - Economy
- Management and prevention
  - Regular measurements
  - Correct analysis
  - Construction quality control
  - Regular maintenance
- Outcome
  - Smoother, safer, more economic infrastructure



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