



# Evaluation of road riding quality using a smartphone-based RTRRMS device

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# Background

- Riding quality indicative of road condition
- Often used in PMS evaluations
- Android RTRRMS application developed in Sweden
- Potentially quicker, easier and up-to-date road roughness measurements for project level evaluations
- Presentation investigate variance in vehicle type, vehicle mass, tyre inflation pressure and vehicle speed



# Structure

- Riding quality background
- Methods of measurement
- RTRRMS
- Pros and cons
- Specific application of Roadroid
- Selected comparisons of data
- Outcomes
- Current and future work (UP VPI)



# Road Roughness?

- Variation in surface elevation that induces vibrations in traversing vehicles
- Different types of roughness associated with different wavelengths



# Road Roughness similar to blood pressure or fever – indicating overall health of the road

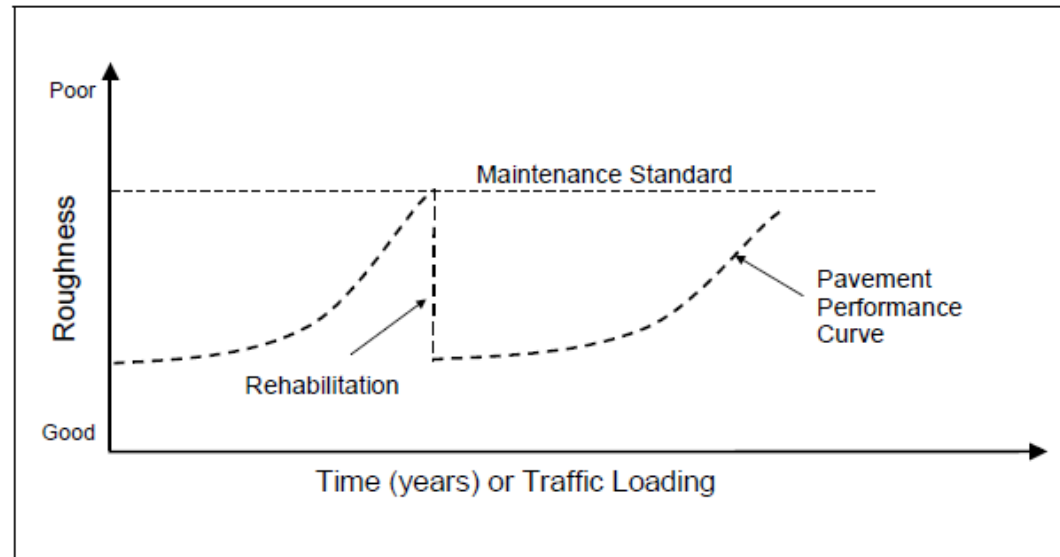


Figure 4.1 Concept of Life-cycle analysis in HDM-4

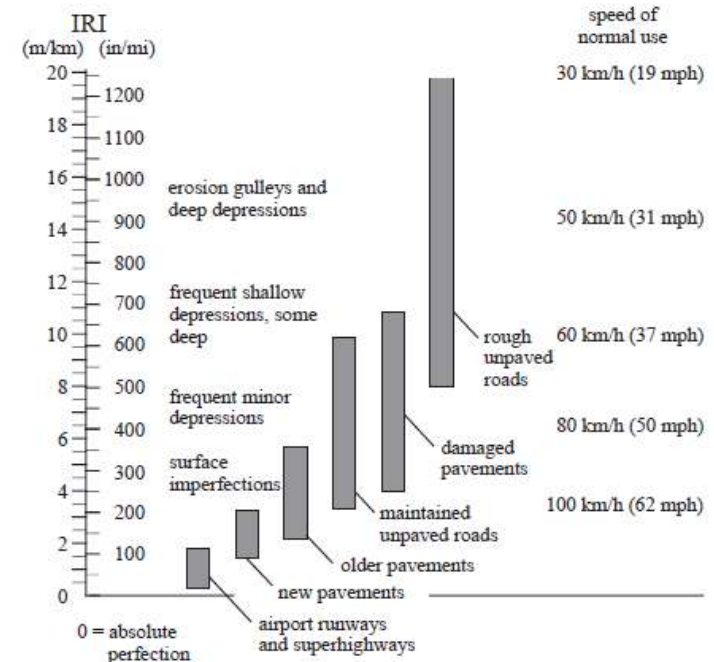
# Rating scales

- Numerous scales available
  - PSI, Quarter-Car Index, Half-car Index, Ride number, TRRI, International Roughness Index (IRI)
  - Profile-based
  - Summary number calculated from numbers that make up profile



# International Roughness Index (IRI)

- Filter based on mathematical model
- Simulated suspension motion accumulated and divided by distance travelled [m/km]
- Reproducible, portable, and stable with time
- Influenced by wavelengths ranging from 1.2 to 30 m
- Linearly proportional to roughness



# Measurement options

- Road profile-based
- Response type Road Roughness Measurements (RTRRM)
- 4 Classes



| <b>Device Class</b>   | <b>Class Requirements or Characteristics</b>  |
|---|---|
| <b>Class 1: Precision Profiles</b>                          | <ul style="list-style-type: none"><li>• Highest standard of accuracy measurement</li><li>• Requires precision measurement of road profiles and computation of the IRI</li><li>• 2 per cent accuracy over 320 m</li><li>• IRI repeatability of roughly 0,3 m/km on paved roads</li><li>• IRI repeatability of roughly 0,5 m/km on all road types</li></ul> |
| <b>Class 2: Non-precision Profiles</b>                      | <ul style="list-style-type: none"><li>• Requires measurement of road profiles and computation of the IRI</li><li>• Includes profiling devices not capable of Class 1 accuracy</li></ul>   |
| <b>Class 3: IRI Estimates from Correlations</b>             | <ul style="list-style-type: none"><li>• Does not require measurement of the road profile</li><li>• Includes all response type devices</li><li>• Devices are calibrated by correlating outputs to known IRI values on specific road sections</li></ul>   |
| <b>Class 4: Subjective Ratings and Uncalibrated Devices</b> | <ul style="list-style-type: none"><li>• Includes subjective ratings of roughness</li><li>• Includes devices for non-calibrated response and profilometric devices</li></ul>   |



# Measurement options

- Road profile
  - Measure actual road profile at selected intervals
- Applications
  - Monitor condition of road network for pavement management systems
  - Evaluate quality of newly constructed or repaired sections
  - Diagnose condition of specific sites and determine appropriate remedies
  - Study the condition of specific sites for research



# RTRRMS

- Adequate for routine monitoring / overall picture of network condition / maintenance needs
- Measured using
  - Displacement transducer on body between axle and vehicle body
  - Vehicle body accelerations
- Output data
  - actual axle body movement versus time of travel
- Disadvantage
  - depends on vehicle dynamics
  - not stable with time
  - not transportable



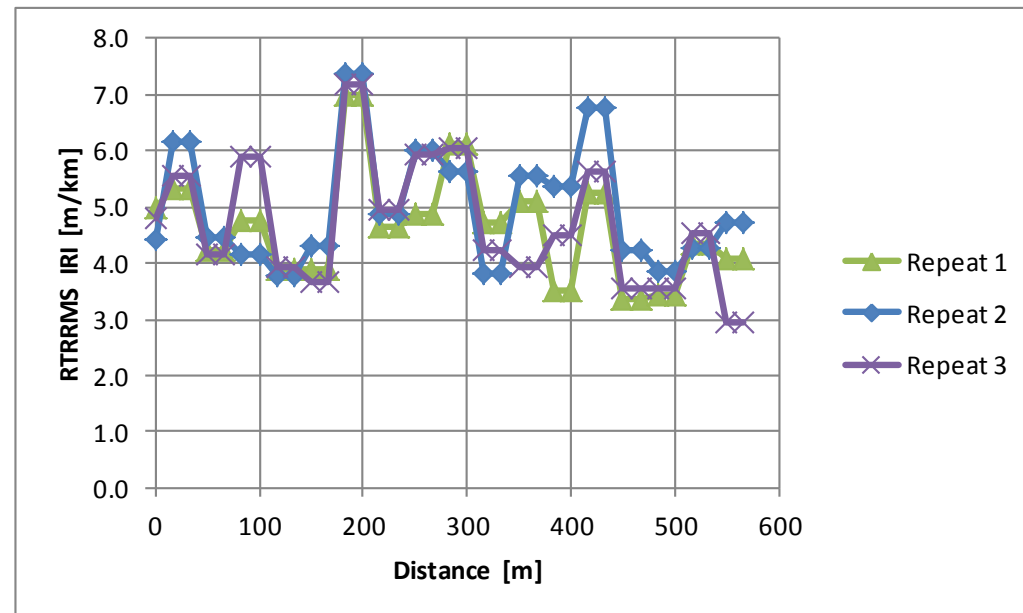
# Specific experiment

- Local evaluation of App
- Evaluate effects of
  - vehicle type (hatchback and LDV)
  - vehicle load (driver and +100 kg)
  - tyre inflation pressure (100% and 80%)
  - Speed (40, 60, 80 km/h)
- Samsung Galaxy S3 with RoadRoid app
- Profilometer-based IRI
- 2 local rural roads



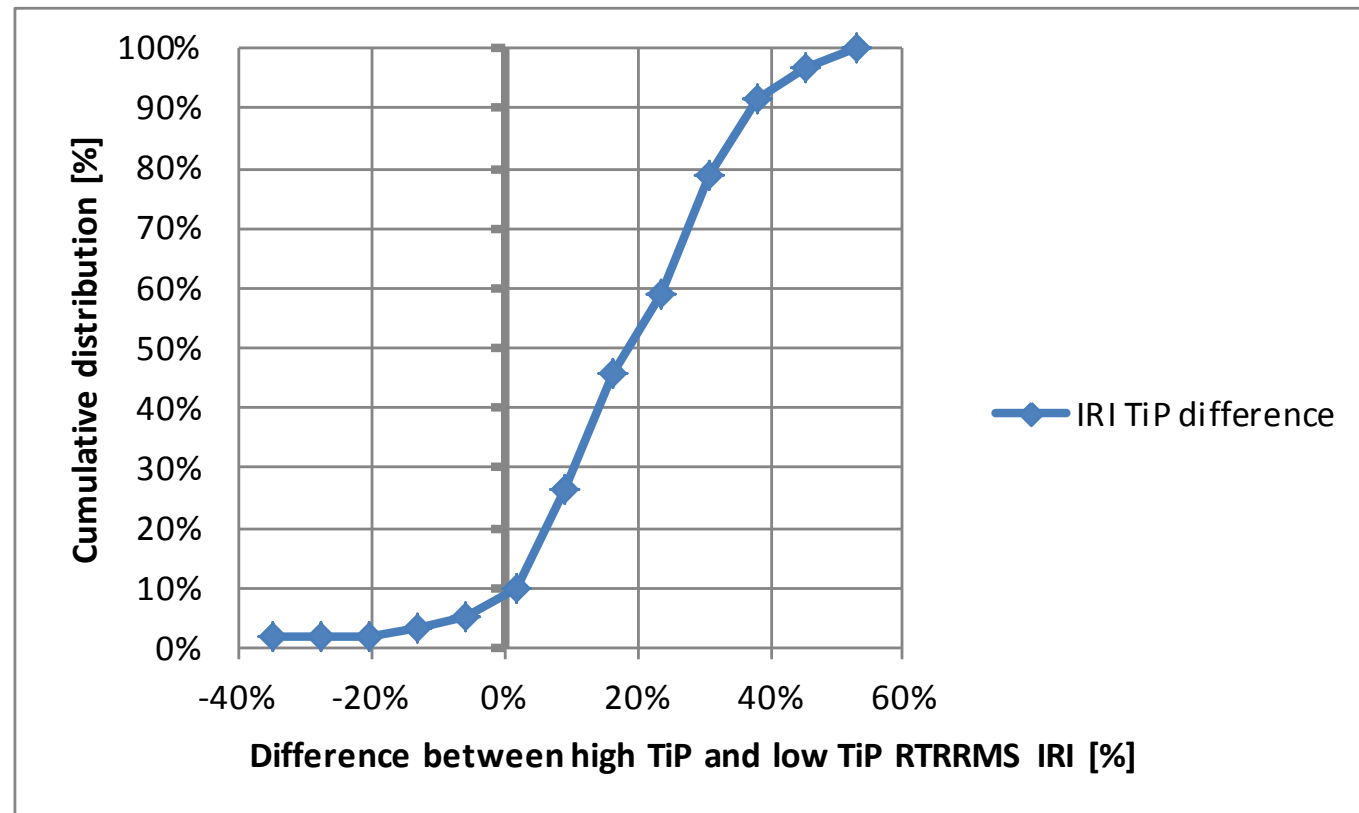
# Selected comparisons - Repeatability

- Consistent speeds
- Slightly different paths – vital for RTRRMS
- Exposed vehicle to different profiles and riding quality
- Data consistent for bulk of measurements



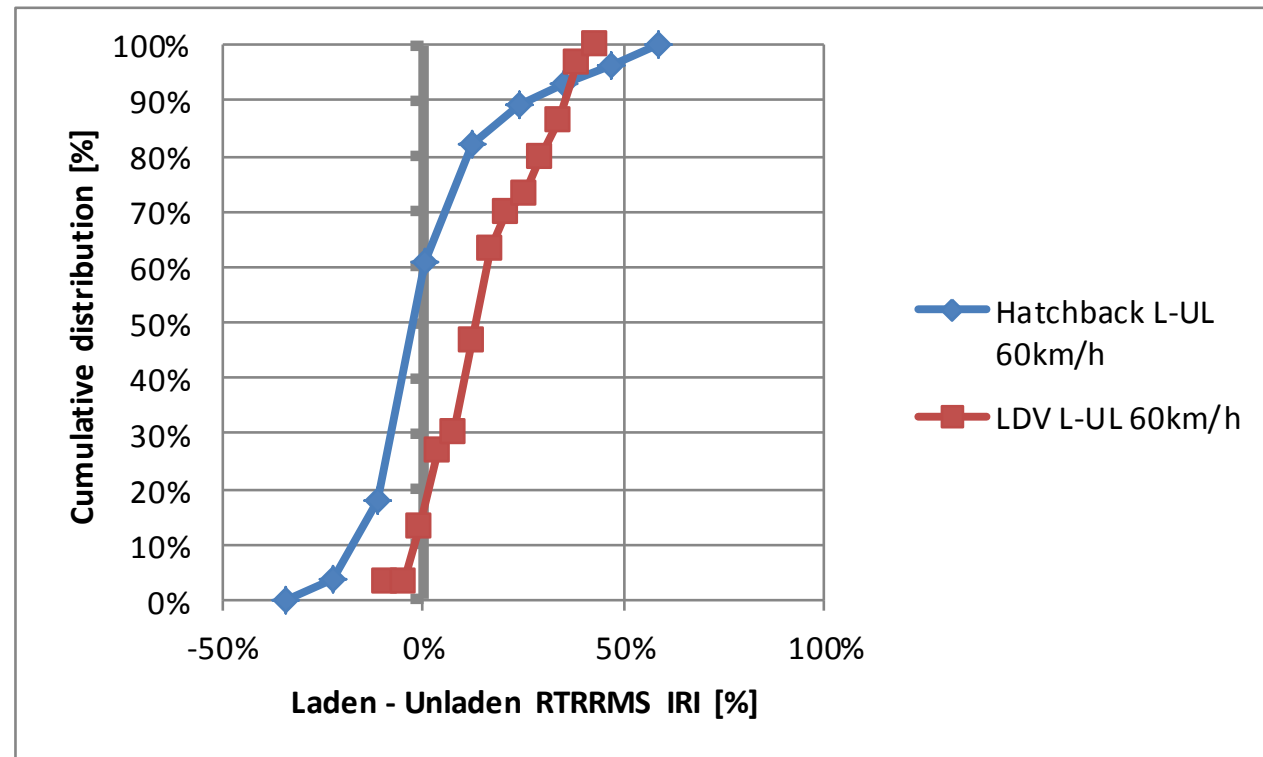
# Selected comparisons – Tyre Inflation Pressure

- Measured roughness higher for higher TiP runs
- Locations of localised anomalies identified



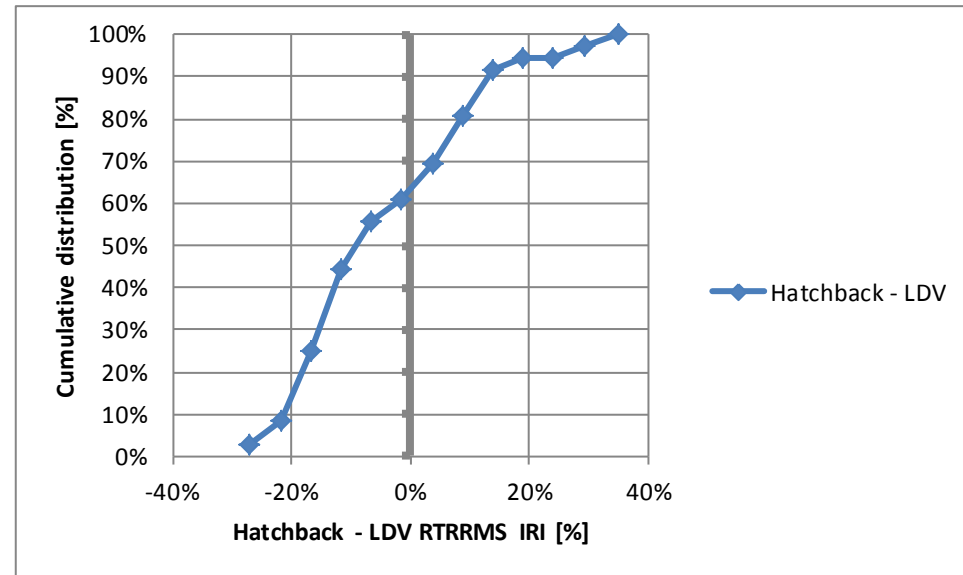
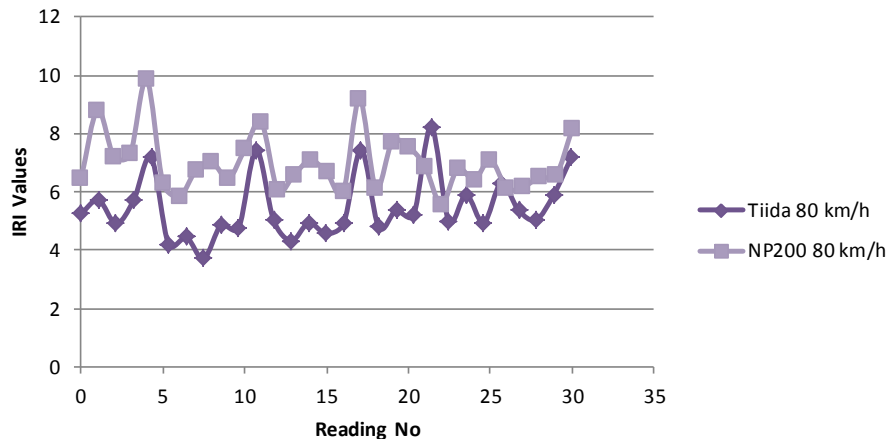
# Selected comparisons – Load levels

- Measured roughness similar for hatchback and increased for loaded LDV
- Most likely reason due to suspension differences



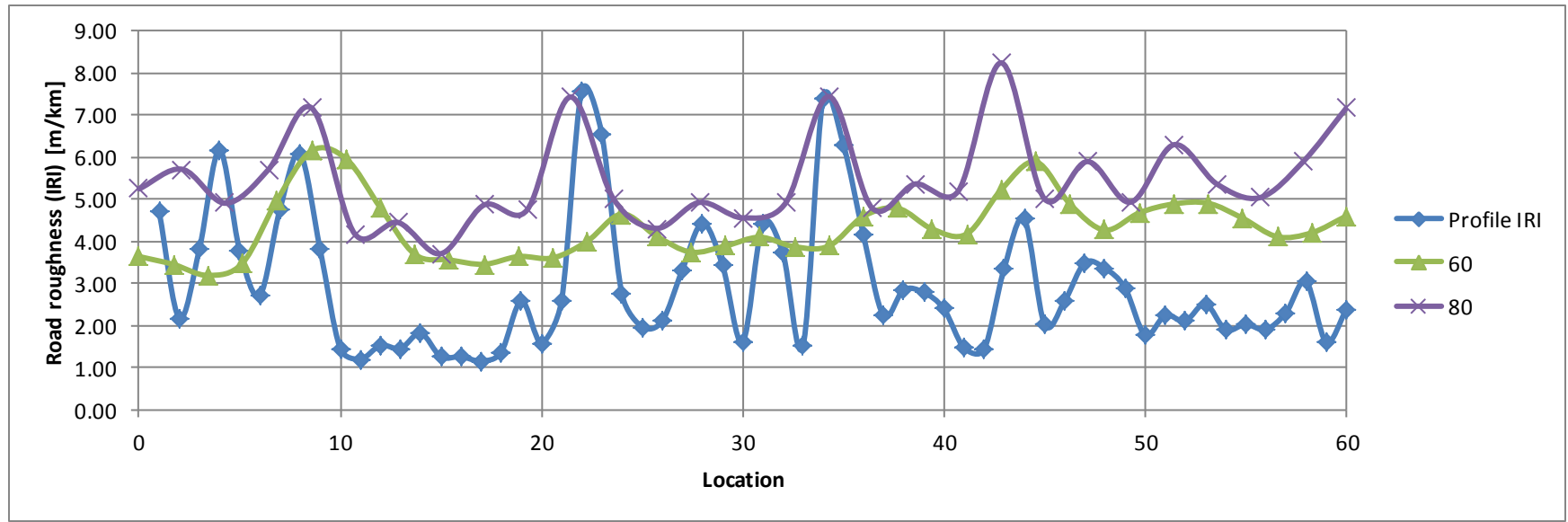
# Selected comparisons – Vehicle types

- LDV showed same or higher roughness data than Hatchback
- Mostly due to suspension characteristics
- Also different drivers for two vehicles
- Less significant influence



# Selected comparisons – Profiler vs RTRRMS data

- Similar patterns in data
- Location of anomalies identified
- Speed, load, type, TiP affected matching





# Recommendations

- Repeatability dependent on vehicle speed and path
- Speed has significant effect on data
- Different loads had less significant effect on data
- Tyre inflation pressure had significant effect on data
- Roadroid perceived as good indicator of roughness (Class 3) – if measurements are well-planned and executed within bounds of instrument



# Current and future work

- UP VPI research tool
- Comparison with other RTRRMS options
- Application and use in academic projects



# Acknowledgements

- Thanks due to Roadroid for support for academic use of app
- Consistent communication and advice

