INNOVATIVE SOLUTIONS
TO COMPLEX PROBLEMS

International Roughness Index (IRI) and Pavement Performance

Hyung S. Lee, PhD, PE

Principal Engineer
hlee@ara.com

December 9th, 2025

ARA

Presentation Outline

- International Roughness Index (IRI)
- Lessons learned from ICT Project R27-199

International Roughness Index (IRI)

- Index for pavement smoothness developed by World Bank in the 1980's

- Definition of IRI from Sayers (1995)

DEFINITION OF IRI

The following points fully define the IRI concept; implications of these points are discussed later:

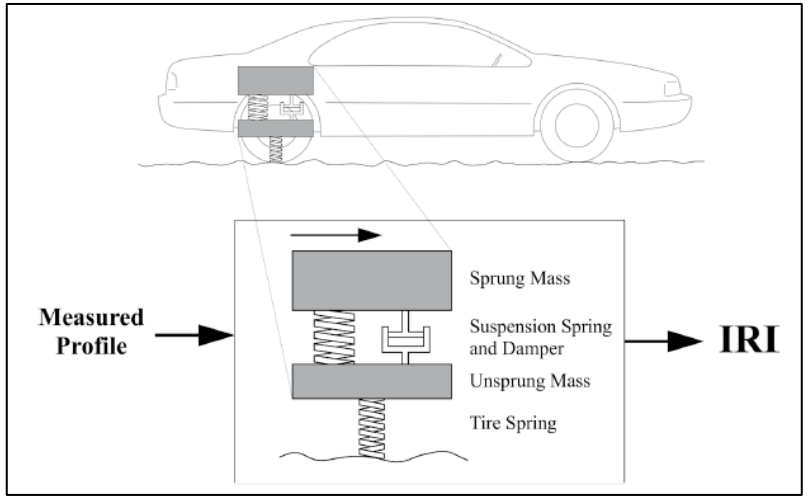
1. IRI is computed from a single longitudinal profile. The sample interval should be no larger than 300 mm for accurate calculations. The required resolution depends on the roughness level, with finer resolution being needed for smooth roads. A resolution of 0.5 mm is suitable for all conditions.
2. The profile is assumed to have a constant slope between sampled elevation points.
3. The profile is smoothed with a moving average whose base length is 250 mm.
4. The smoothed profile is filtered using a quarter-car simulation, with specific parameter values (Golden Car), at a simulated speed of 80 km/hr (49.7 mph).
5. The simulated suspension motion is linearly accumulated and divided by the length of the profile to yield IRI. Thus, IRI has units of slope, such as inches per mile or meters per kilometer.

From Sayers (1995)

4. The smoothed profile is filtered using a quarter-car simulation, with specific parameter values (Golden Car), at a simulated speed of 80 km/hr (49.7 mph).

5. The simulated suspension motion is linearly accumulated and divided by the length of the profile to yield IRI. Thus, IRI has units of slope, such as inches per mile or meters per kilometer.

Quarter-Car Model



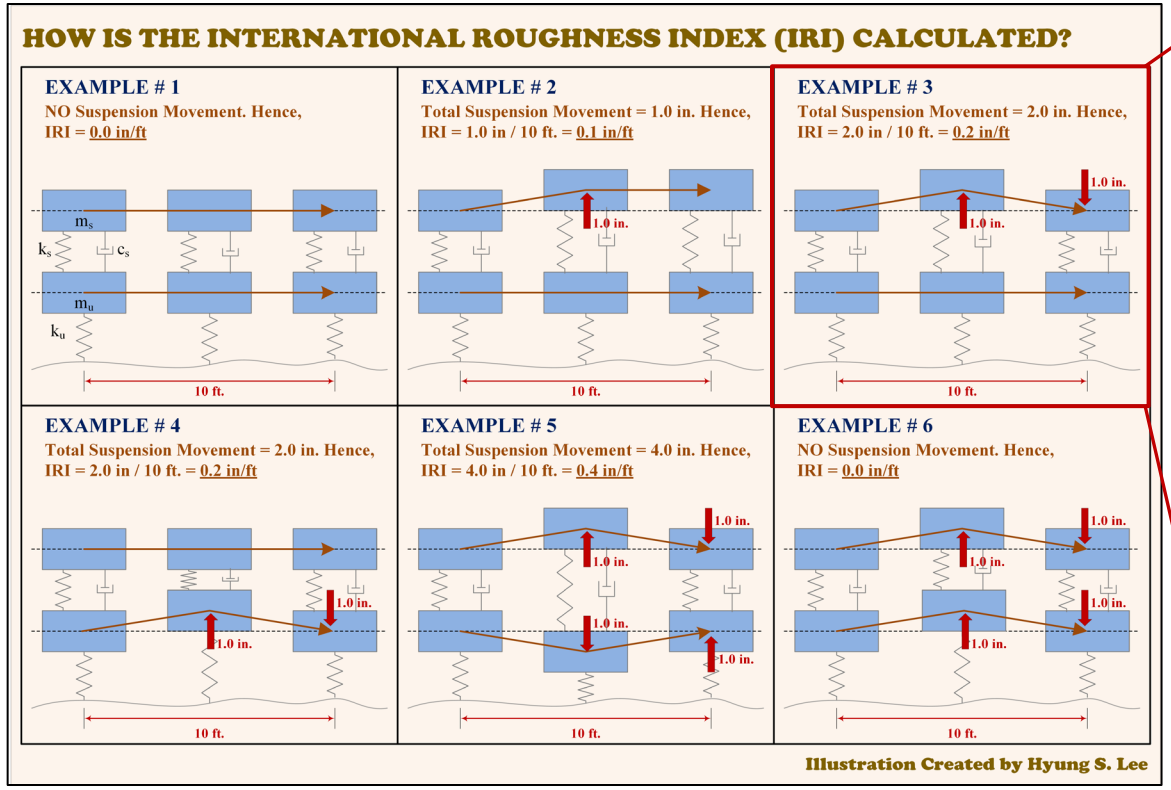
From Karamihas and Sayers (2025)

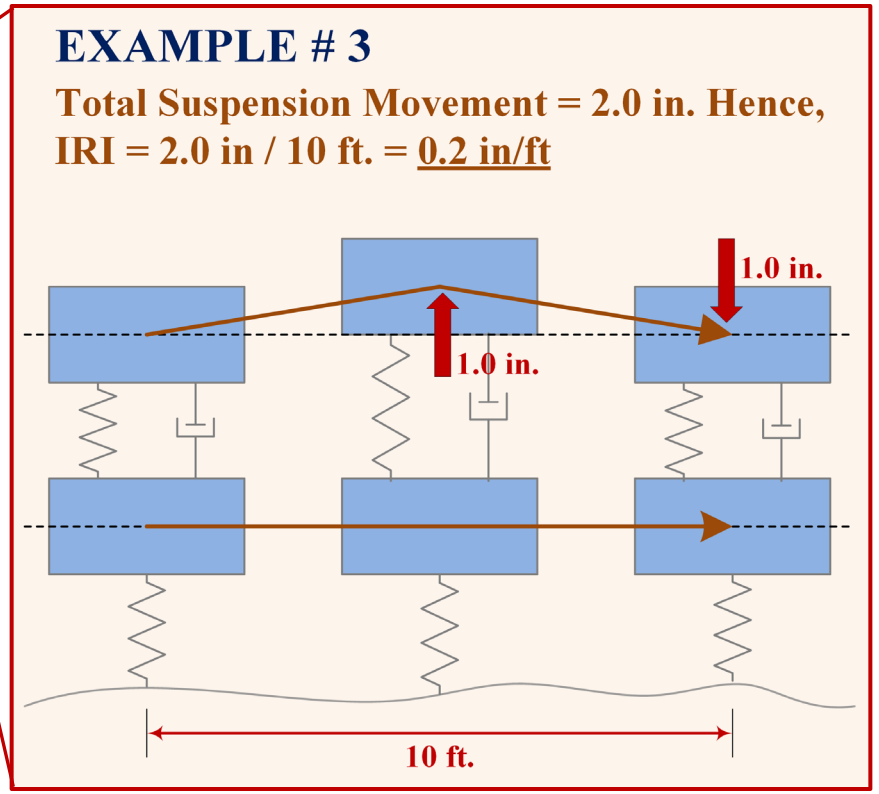
- **WHAT DOES THIS MEAN?**

References:
1. Sayers, M.W. (1995). On the Calculation of International Roughness Index from Longitudinal Road Profile. TRR, No. 1501. pp. 1-12.
2. Karamihas, S.M. and Sayers, M.W. (2025). The Little Book of Profiling, 2nd Ed. UMTRI-2025-4

What is IRI?

- IRI = (Accumulated Suspension Movement) / (Distance Traveled)
- Explanation with some unrealistic examples…



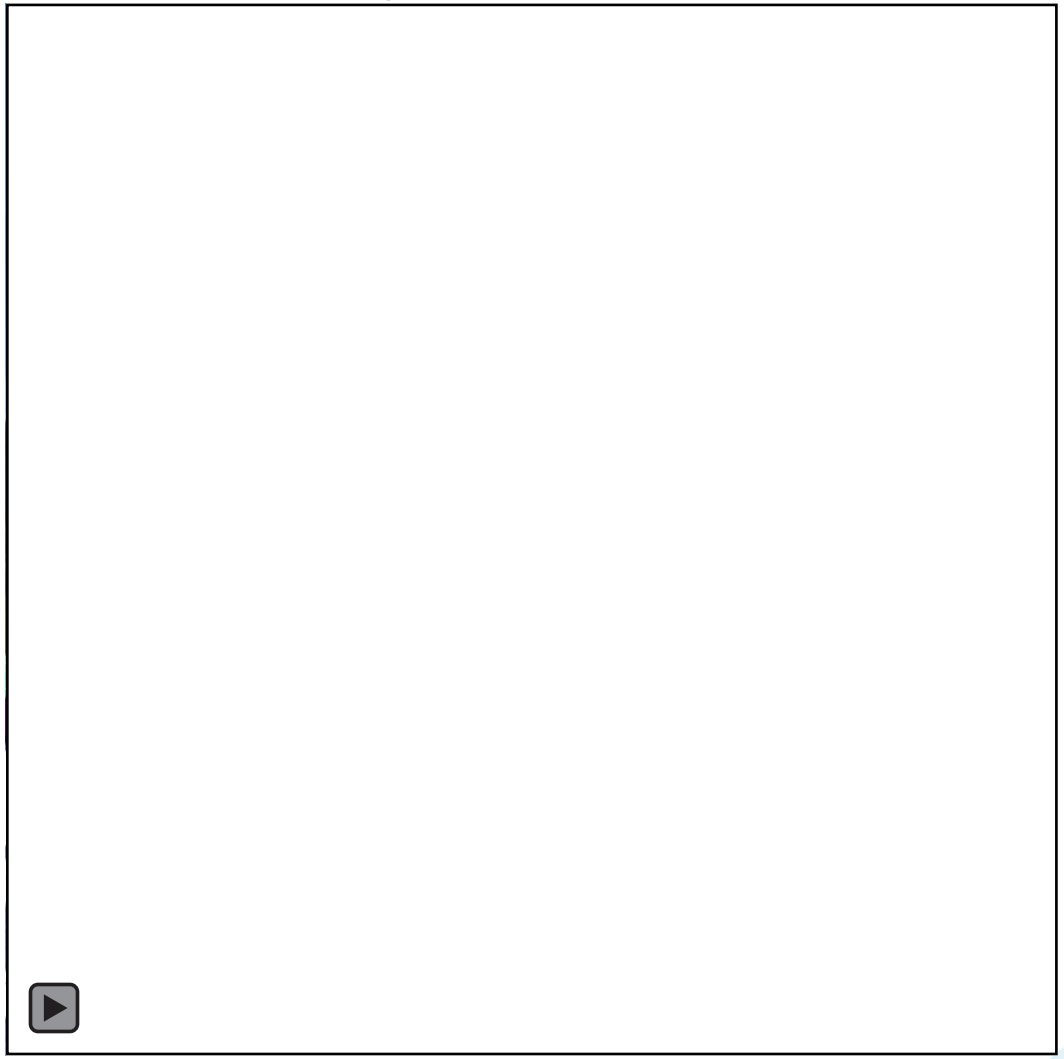


For full explanation, please visit:
https://www.linkedin.com/posts/hyungsuklee_roughness-iri-profile-activity-7302880648757739520-B0yc?utm_source=share&utm_medium=member_desktop&rcm=ACoAABnhbqcBvuVeba7sL0lDQXHJae3l0Orc1OI

“Golden Car” is About 40 Years Old…

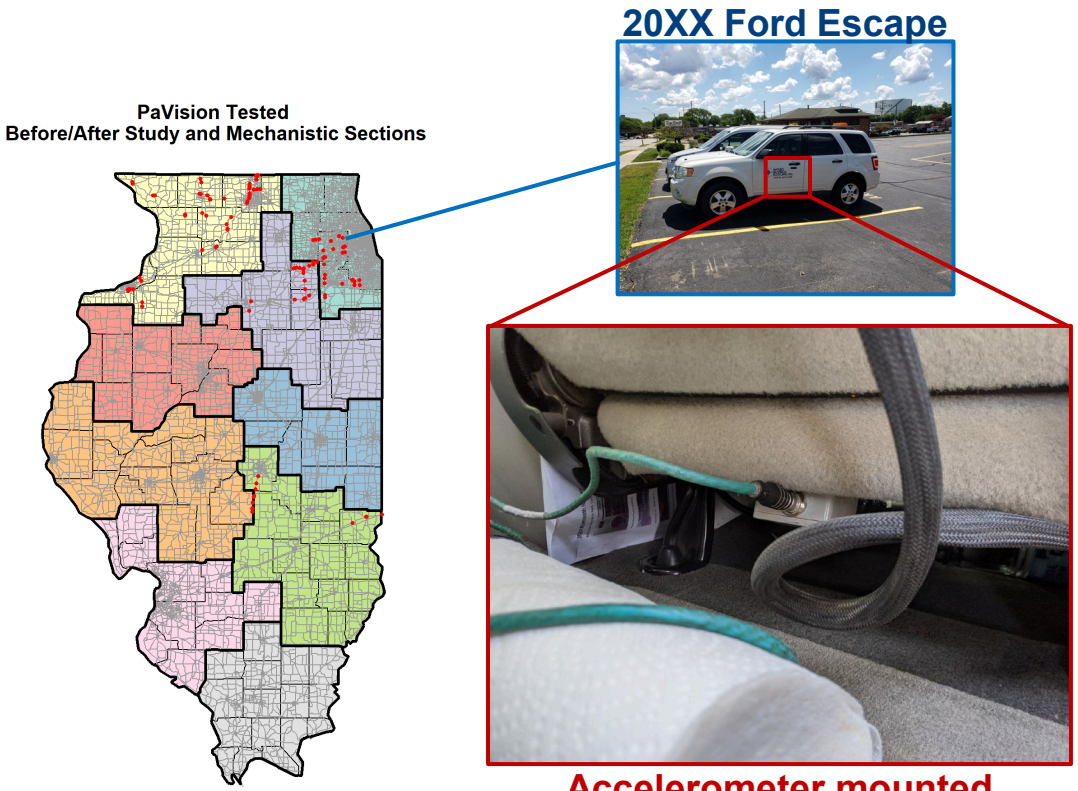
- Is it representative of vehicles we have today?
  - Depends on many things
- Is it realistic?
  - Maybe, Maybe Not…
- **The important question:**
  - **Does it represent user comfort or ride quality well?**

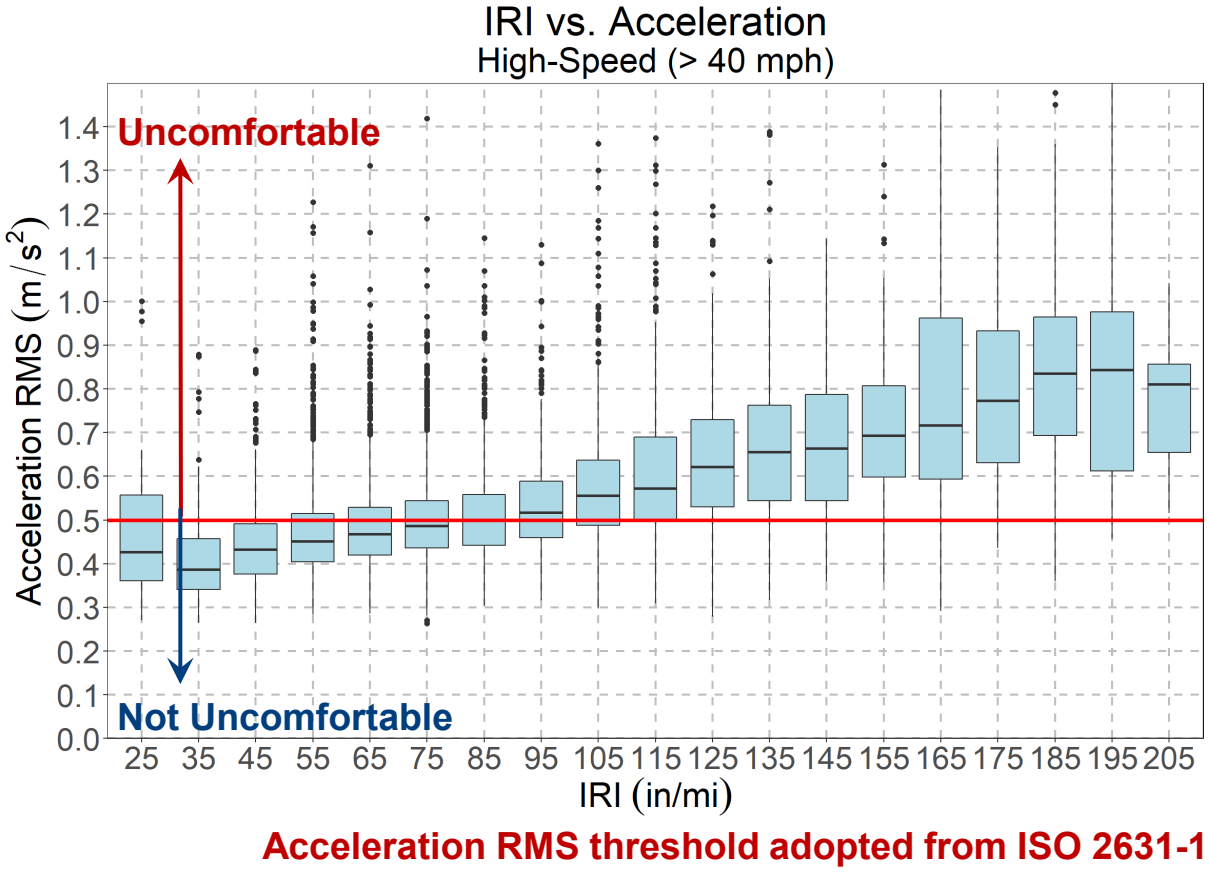
Simulation of a “Ride” on top of the theoretical Quarter Car (Rough Flexible Pavement)



IRI vs. User Comfort (From ICT Project R27-199)

- Driver seat acceleration data collected on multiple roadways with recent IRI data



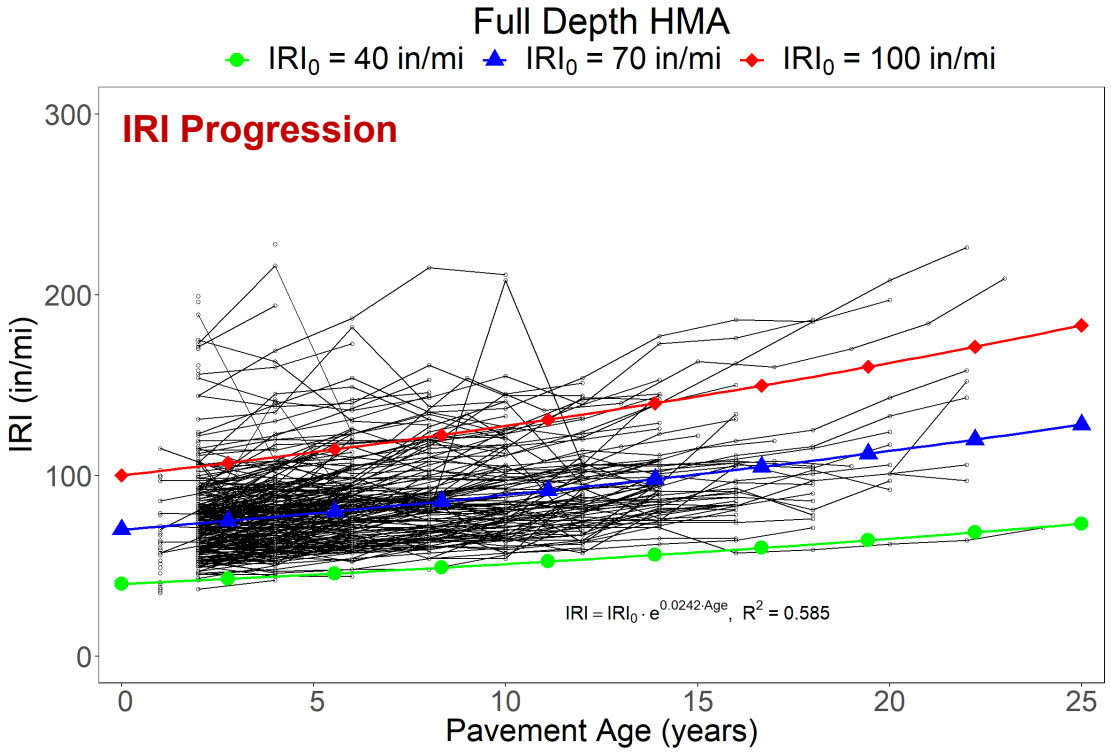


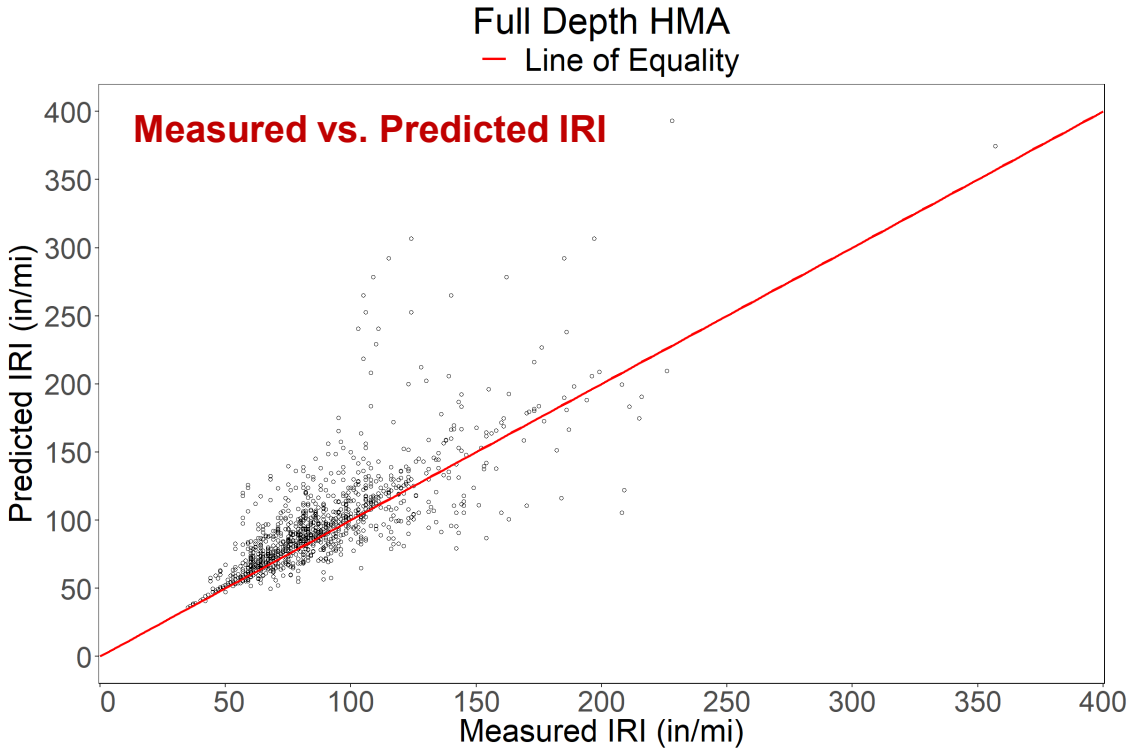
Acceleration RMS threshold adopted from ISO 2631-1

- **The lower the IRI, the better the ride quality (or user comfort)**

IRI Progression (From ICT Project R27-199)

- Based on Illinois Roadway Information System (IRIS) data from 1973 to 2017
- Empirical IRI model developed as a function of Initial IRI and Pavement Age

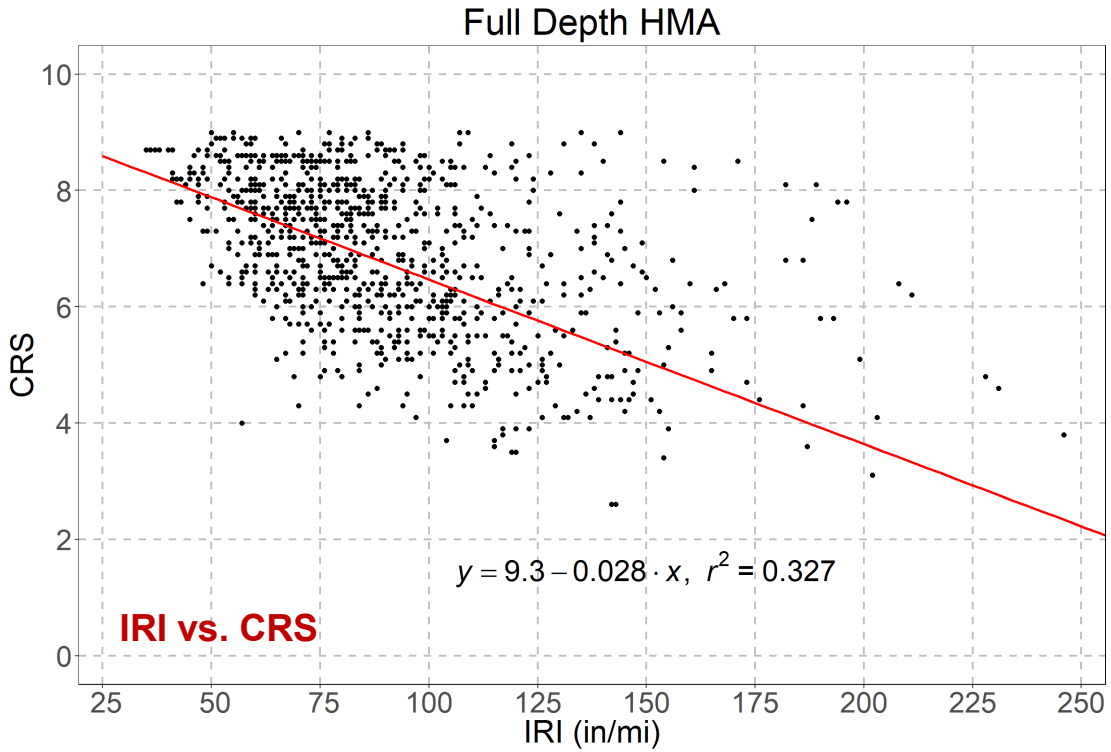


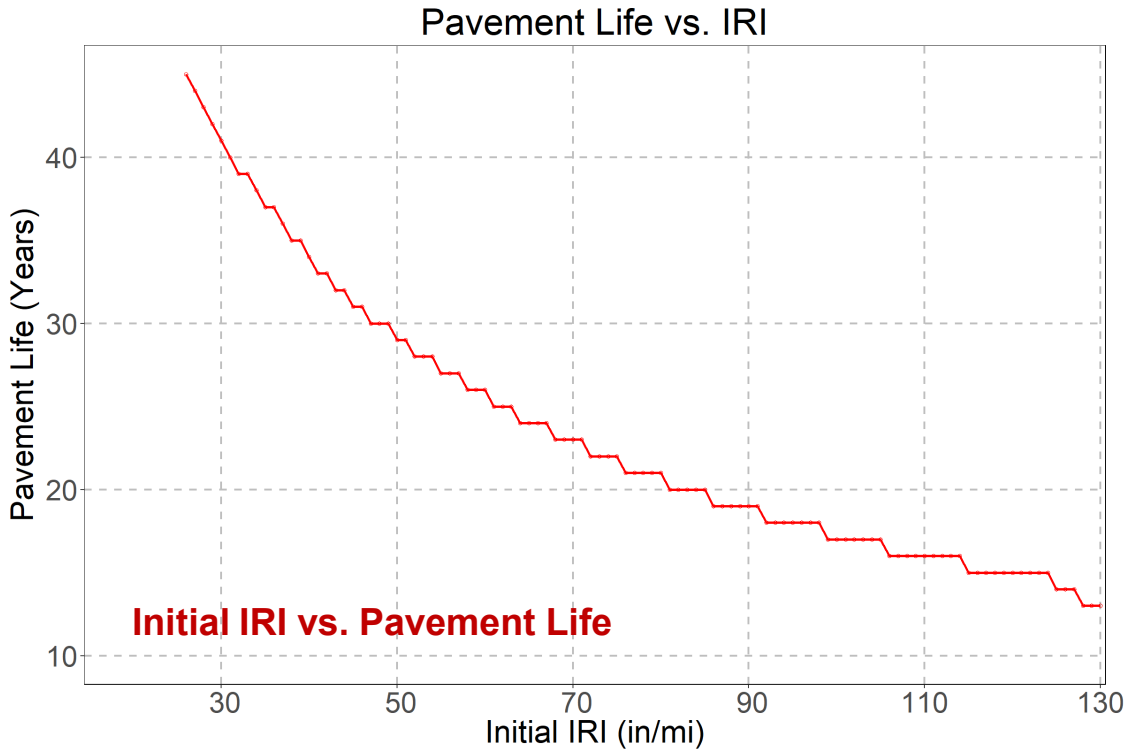


- **Smoother pavements remain smoother!**

IRI vs. Performance (From ICT Project R27-199)

- Empirical relationship between IRI and Condition Rating Survey (CRS) score
  - Used for Life Cycle Cost Analysis (LCCA)





- **Smoother pavements perform better and last longer!**

Why Do We Want Smooth Pavements?

- Smoother pavements remain smooth, perform better, and last longer!

- Other benefits
  - Reduced Life Cycle Cost (LCC) for the agency
  - Reduced user cost (e.g., fuel consumption)
  - Improved safety

- For more information, please see ICT Project R27-199 Final Report
  - Title: “Development of IDOT’s Proposed Smoothness Specification Based on the International Roughness Index”
  - https://apps.ict.illinois.edu/projects/getfile.asp?id=9329

Thank you!