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In-vehicle Evaluation of Rumble Strips in Pre-and Post-chip Sealed Maintenance Periods

Ernest Tufuor, Ph.D. Student, & Laurence Rilett, Professor, Department of Civil Engineering

MOTIVATION

- ❑ Chip sealing will reduce the depth of rumble strips (RS) by approximately 1/8".
- ❑ Will this depth reduction affect RS functional characteristics (audible and tactile warnings)?
- ❑ There is no detailed study on the effectiveness of RS that have been chip sealed.

OBJECTIVE

- ❑ Measure the in-cab noise and vibration responses to changes in the depth of milled RS caused by chip sealing at
 - ✓ Different RS depths (1/8" reductions)
 - 5/8", 1/2", 3/8", 1/4", and 1/8"
 - ✓ Different vehicle speeds
 - 45 mph, 55 mph, and 65 mph
 - ✓ Two vehicle types
 - Passenger Car and Pickup Truck.

USEFULNESS

The results will be useful to the Nebraska Department of Roads to determine:

- ❑ **Operations**
 - ✓ Whether RS will need to be re-milled after chip sealing. Cost & safety implications.
- ❑ **Design**
 - ✓ New RS guidelines for highways expected to be chip sealed in the future.

MEASUREMENT UNITS

- ❑ Sound was measured in an A-weighting logarithmic scale (dBA) that is known to mimic human hearing. A change >6 dBA is noticeable.
- ❑ Vibration was measured as the rate of change of motion in the vertical direction. A change of >0.5 m/s² is known to be uncomfortable.

DATA COLLECTION METHODOLOGY

1. Test Sites and Conditions

- ❑ Test beds were on three highways in Nebraska; at Milford, Seward, and Crete.
- ❑ Data was collected under good weather conditions

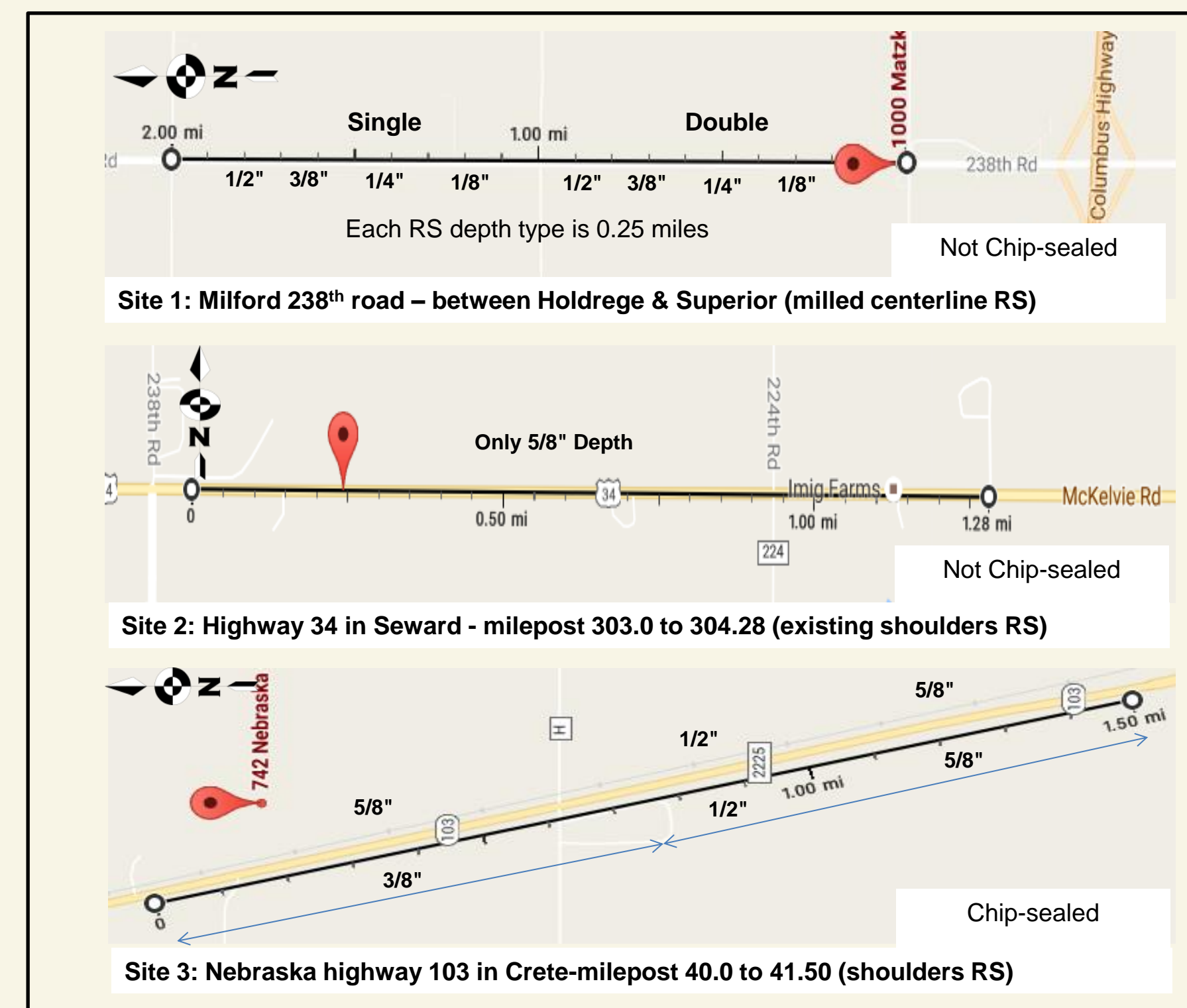


Fig. 1. Description of test sites showing location and RS types (Source: google maps)

2. Data Collection System (DCS)

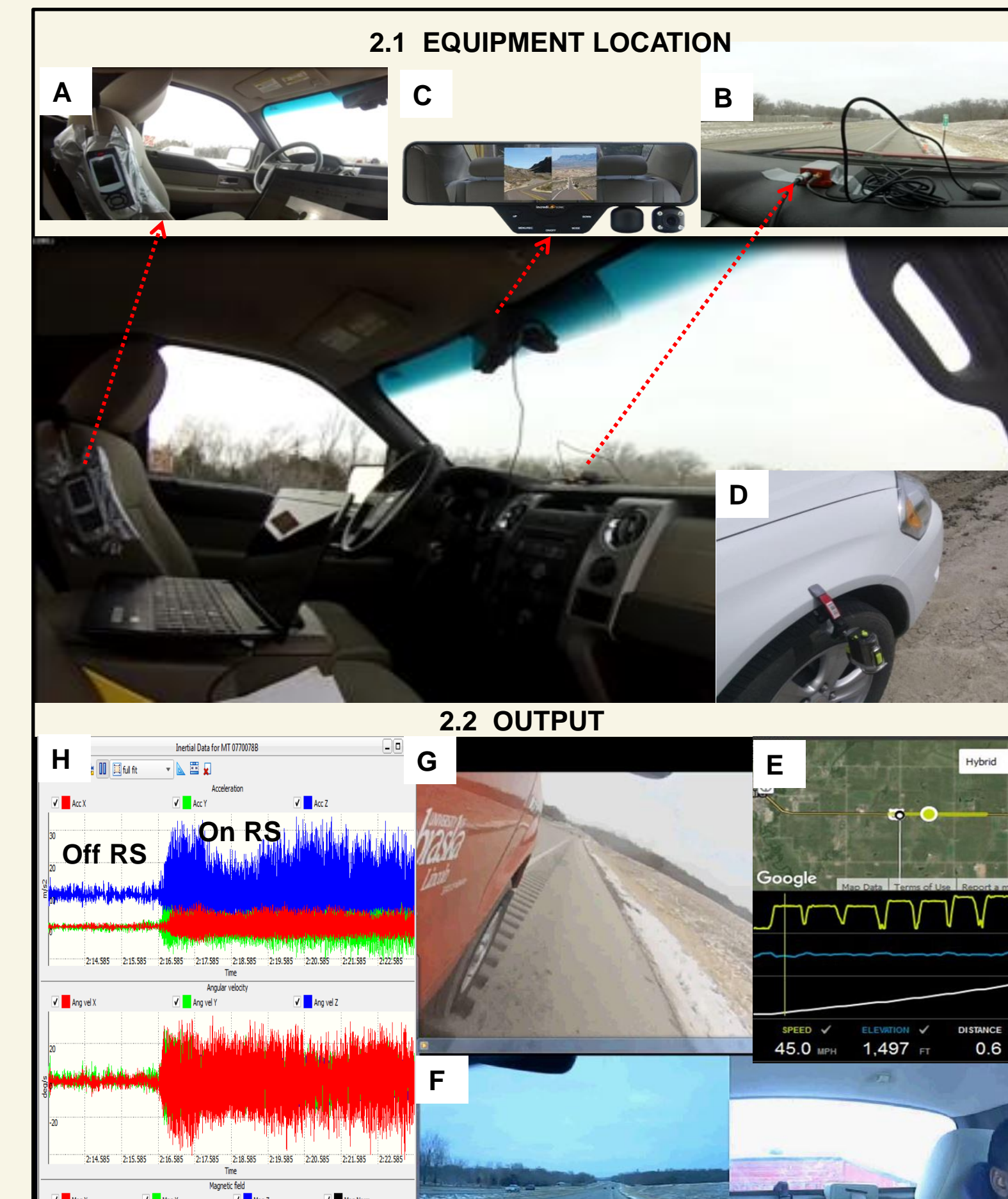


Fig. 2. Equipment setup and data collection process

EQUIPMENT (DCS)	LOCATIONS (DCS)	OUTPUT (DCS)
SOUND LEVEL METER	A – On Driver Seat at Ear Level	H – Shows Sound & Vibration Readings on RS and off RS
VIBRATION SENSOR	B – On Dash Board	F – Record In- & Out-Vehicle Activities
HD MIRROR CAMERA	C – On Driving Mirror	E & G – Speed Profile & Tire-RS Contact
CONTOUR CAMERA	D – On Vehicle Fender	

RESULTS – 1. Sound Analysis

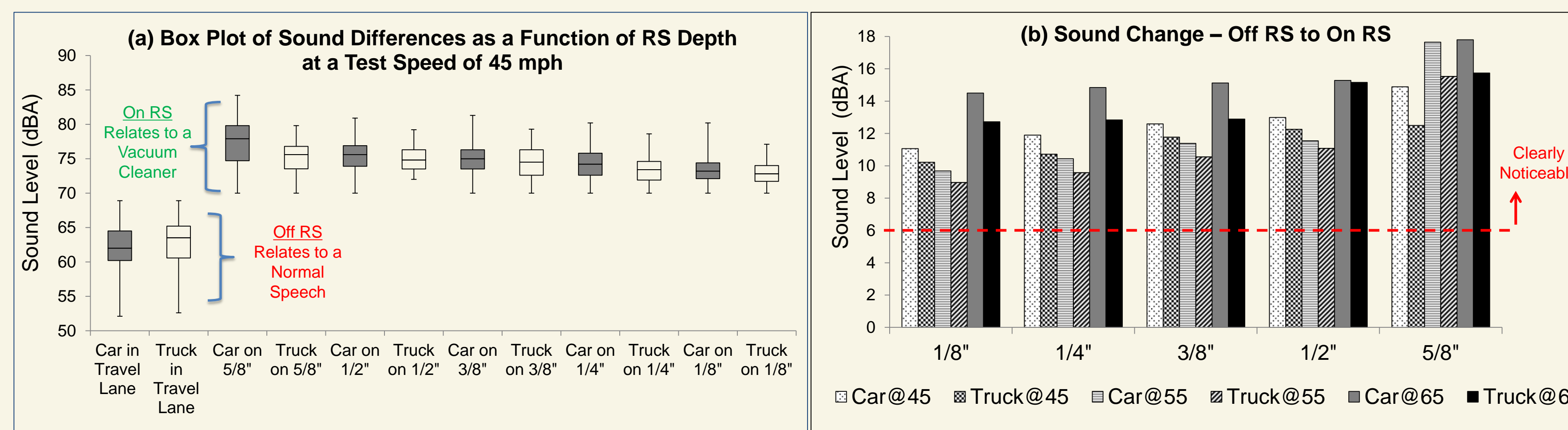


Fig. 3. (a) Shows the sound level readings when the test vehicle is in the travel lane (off RS) and when on the RS, and (b) Depicts the change in sound levels between when vehicle is off RS and on each RS depth at a specific speed

RESULTS – 2. Vibration Analysis

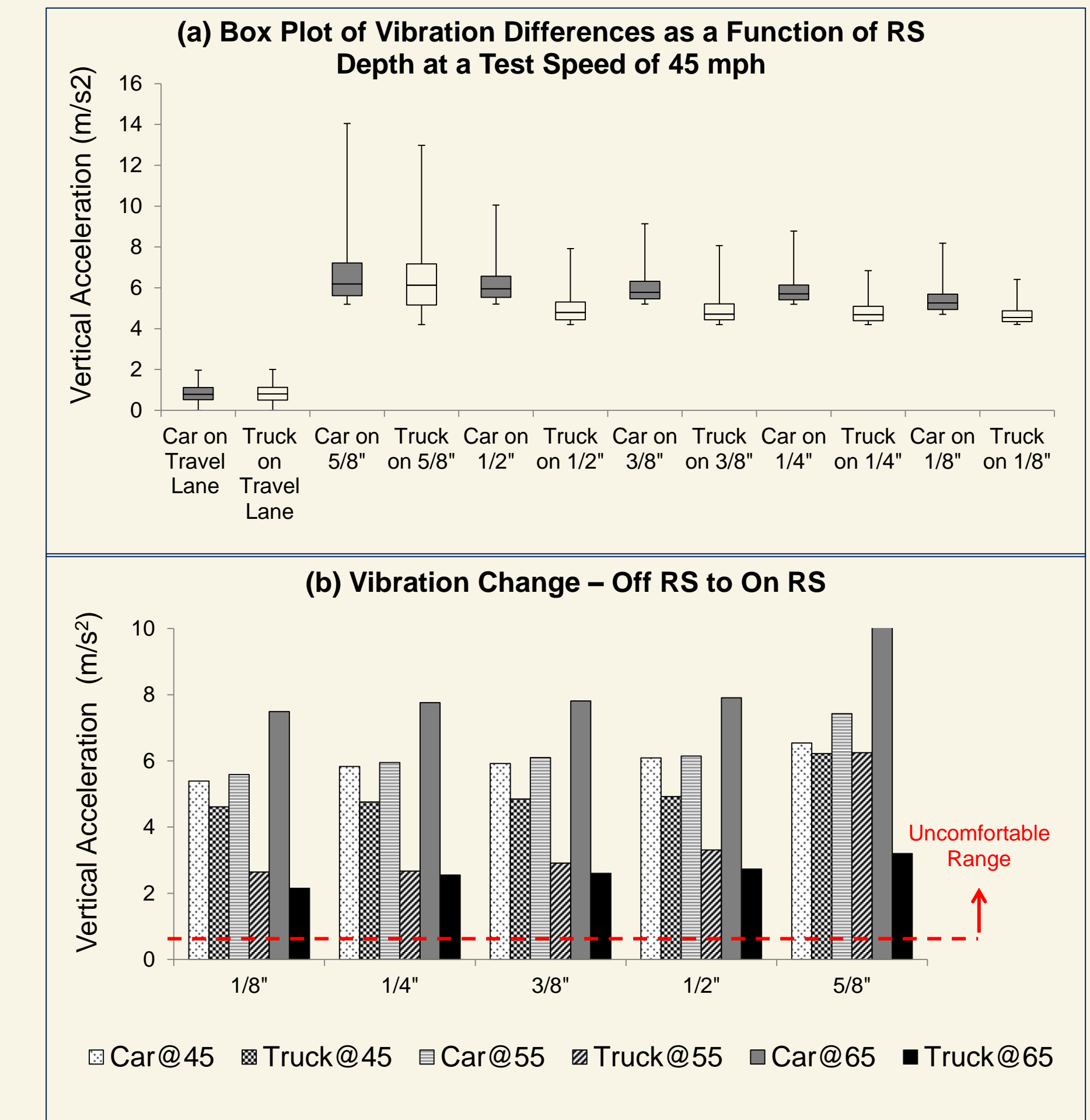


Fig. 4. (a) Shows vibration readings between off RS & on RS, and (b) Depicts the change in vibration readings

CONCLUSION

- ❑ It can be shown that a **1/8" reduction** in the current milled **RS design depth**, as a result of chip sealing, **does not** result in a practical reduction in the RS effectiveness at producing audible and tactile warnings to alert drivers.
- ❑ There are statistically significant differences between the in-vehicle noise levels and vibration levels when vehicles are in a travel lane (off RS) and when on a chip-sealed RS.
 - ✓ The difference will be clearly noticed by an average driver using a car or pickup truck at speeds of 45 mph, 55 mph, and 65 mph.