

Friction as a Measure of Slippery Road Surfaces

Taisto Haavasoja¹ and Yrjö Pilli-Sihvola²

¹Teconer Oy, Helsinki, Finland

E-mail: name.surname@teconer.fi


²ELY Centre for Southeast Finland, Kouvola, Finland

E-mail: name.surname@ely-keskus.fi

Contents

- Icing of a road surface covered with a salty solution
 - What does freezing point mean?
- Basics of friction
 - physical meaning, braking distance
- Practical means of measuring friction
 - force based means
 - indirect means
 - acceleration based means

Icing

- Freezing of water and deicer solutions
 - Depression of Freezing Point (DFP)
- When temperature drops below DFP, 
 1. only a fraction of solution freezes
 2. the composition of ice and solution is softer than ice formed from clean water
 3. friction on a mixture of solution and ice is appreciably higher than without the solution

Icing: consequences

- clean water to ice:
 - 30 μm layer of ice can reduce friction dramatically
 - 1 mm of hard ice, friction may be < 0.20
- solution of water and deicer chemical:
 - 1 mm of soft ice, friction likely > 0.40

Prevention of Low Friction

1. Presalt at the right time!
 - avoid hard ice
2. Follow development of friction.
 - refreezing is a slow process!
3. Apply more salt if needed.

Friction Basics

- By definition

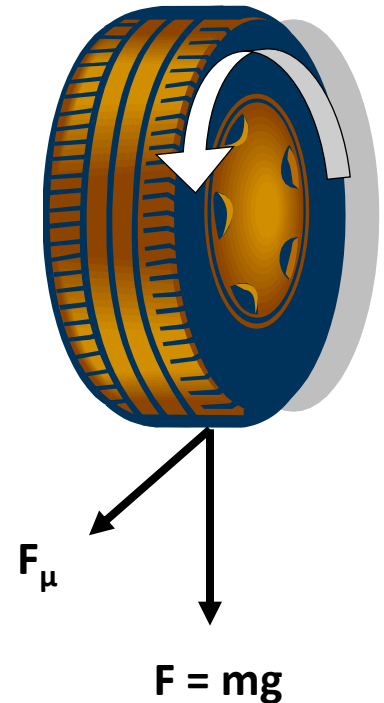
$$\mu = F_{\mu} / F$$

- Since during braking

$$F_{\mu} = m a,$$

where a is deceleration, we get

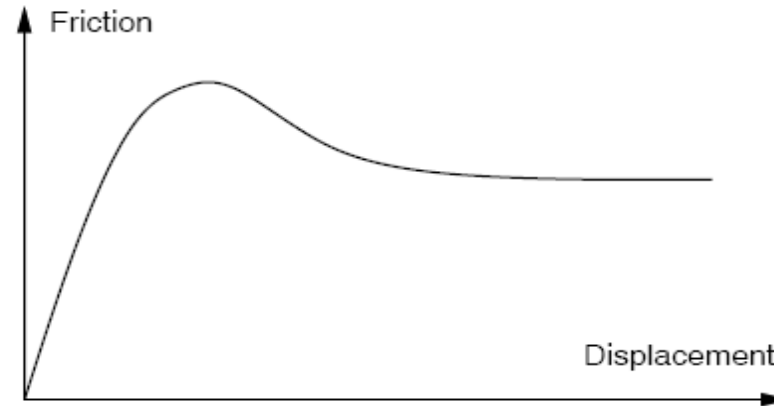
$$\mu = a / g \quad (g = 9.81 \text{ m/s}^2)$$



Consequences

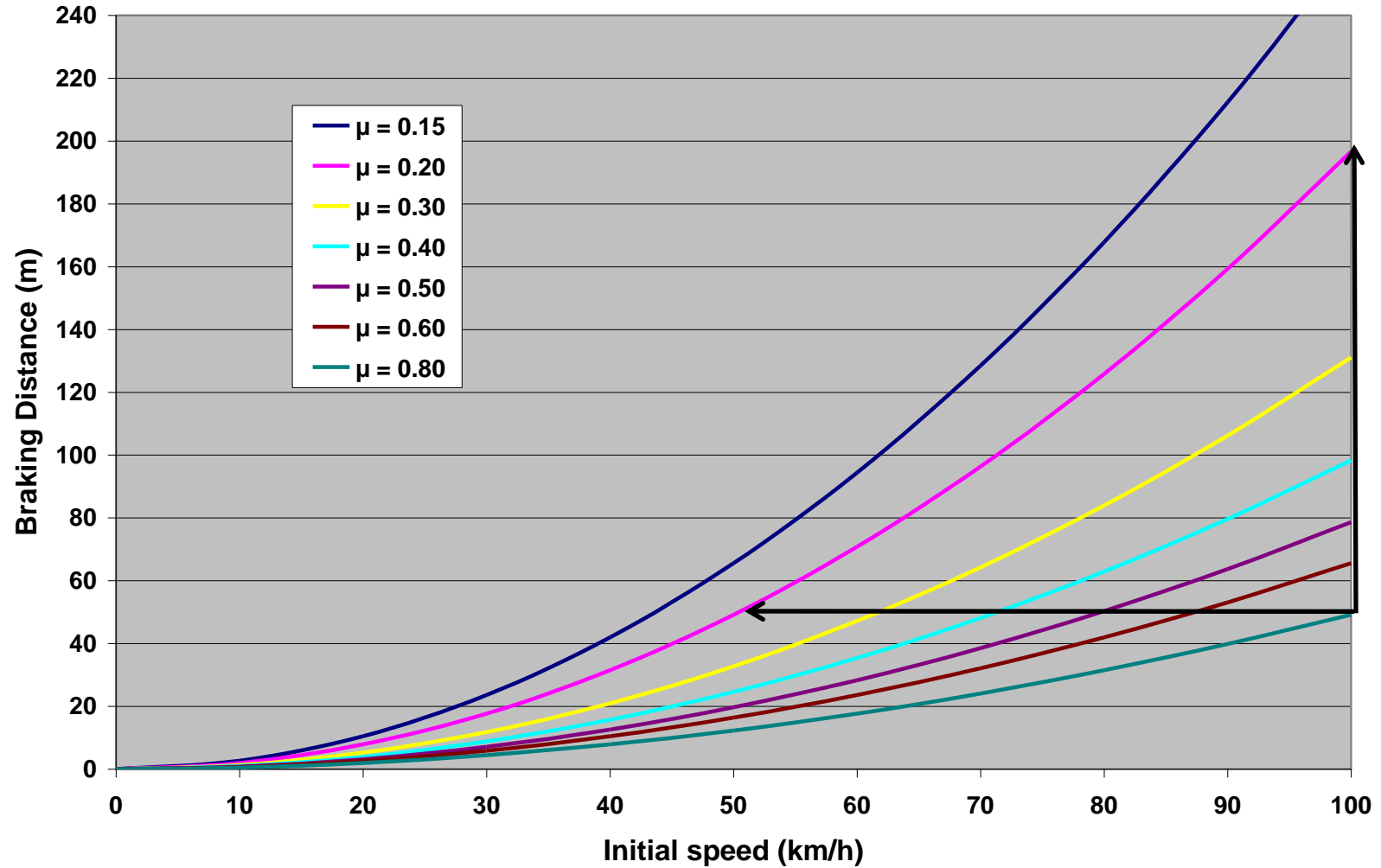
- if all tires are active in braking
 - deceleration equals friction
 - friction is independent of the mass of the vehicle
- friction is a unique measure of slipperiness
 - friction is an absolute quantity
 - no units, since ratio of forces
- typical variation of friction:
 - dry road 0.80 ± 0.10 (depends on tire and surface conditions)
 - hard ice 0.20 or less (all tires when thick layer of hard ice)

Friction and Slip



- maximum in friction force at about 20 % slip
- [Olsson et.al., Friction Models and Friction Compensation](#)
- practical measurements for winter maintenance
 - enough to know friction in increments of 0.10

Braking Distance



Measuring Friction by Force

- typically "a third wheel" on a trailer or an extra wheel
- numerous manufacturers
- advantages for road use
 - continuous data
 - accurately calibrable
- disadvantages
 - cost
 - difficult to use
 - temperature effects

Friction measuring vehicles:

1. Instrumented Tire Test Vehicle (Truck)
2. Diagonal-Braked Vehicle
3. Mu-meter trailer
4. BV-11 skiddometer trailer
5. GripTester trailer
6. Surface friction tester
7. Runway friction tester
8. Tatra friction tester
9. ASTM E-274 skid trailer
10. Dynamic friction tester
11. Norsemeter variable slip friction tester
12. IMAG variable slip friction trailer
13. James Brake Index decelerometer vehicle
14. Portable helideck friction tester
15. Portable drag-slip tester
16. Penn State skid trailer
17. BV-14 skiddometer trailer

(Ref: 15th Nasa Tire/Runway Friction Workshop)

Friction by Indirect Means

- determine friction by a model
 - detect surface coverage, weather conditions, ...
 - work out a correlation between the environmental variables and the measured friction
- Vaisala Remote Road Surface State Sensor DSC111
 - measures water, ice and snow layer → reports friction



DSC111 Installed to a Vehicle

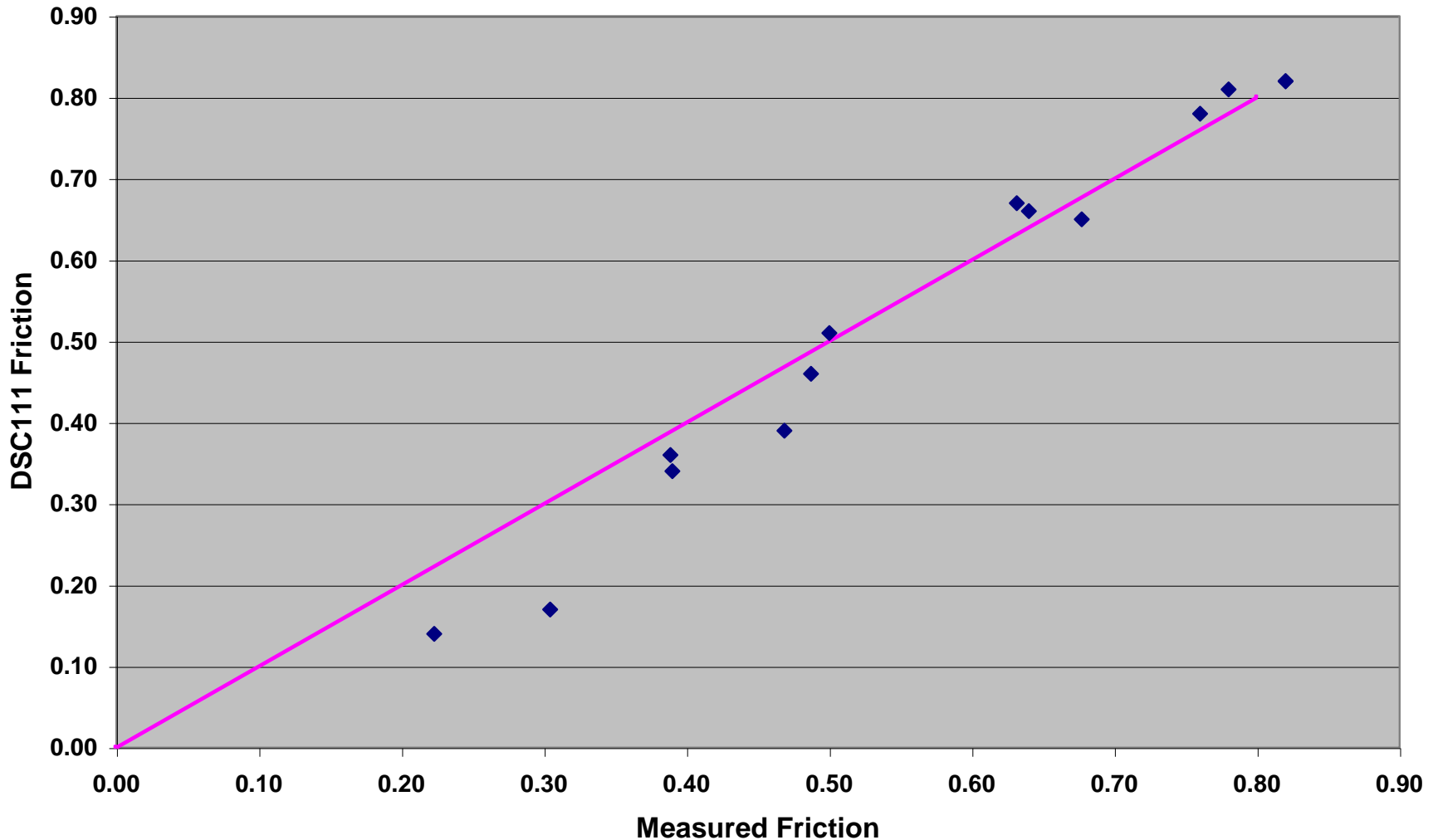


Test Run on Highways E12 – E18



Temperature about -6 °C: wheel tracks slippery on E12, not on E18.

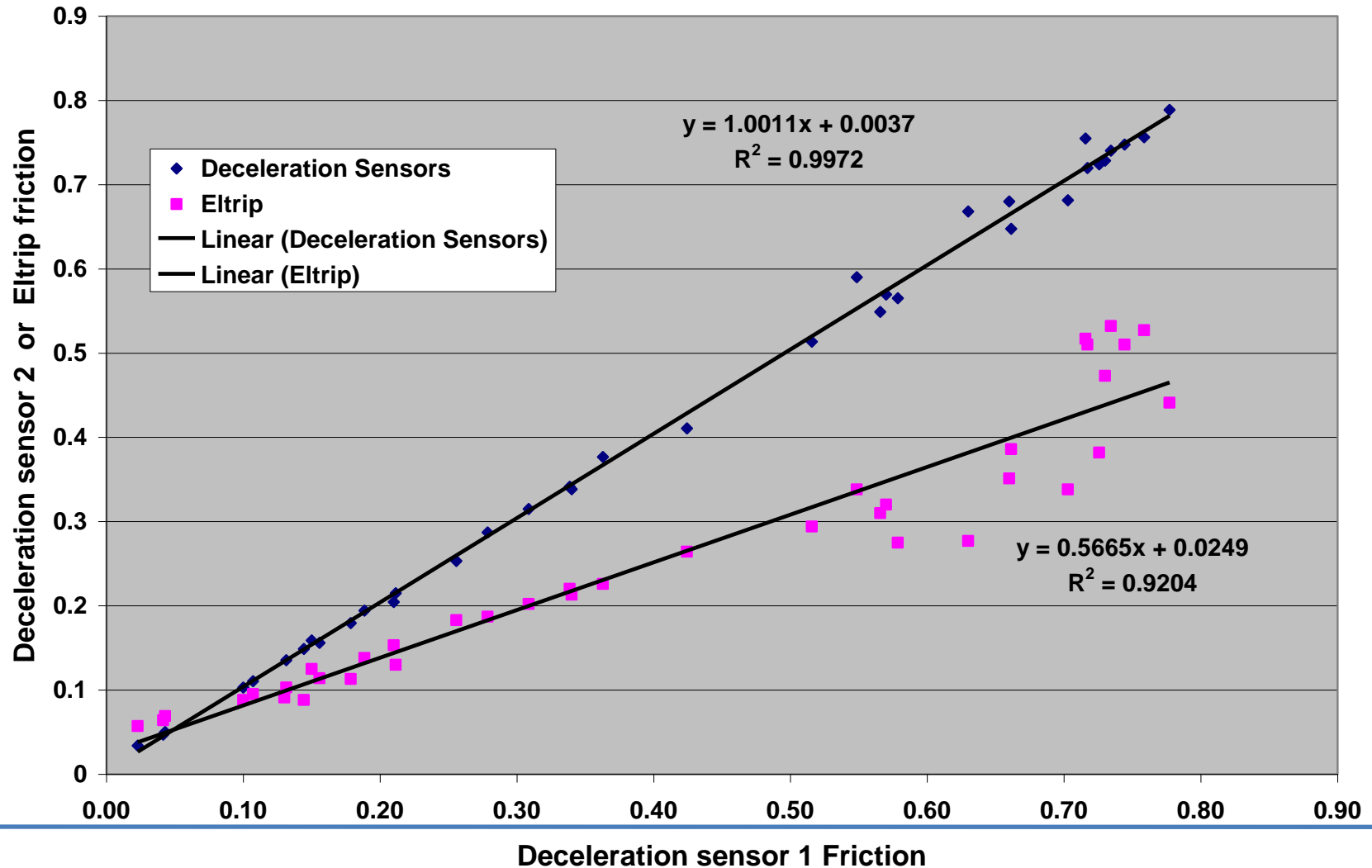
DSC111 Friction vs. Deceleration



Friction Meters by Acceleration

- older models measure
 - force on a macroscopic piece of mass during braking or
 - change of speed while braking ← Watch out!
- nowadays
 - digital micro-electro-mechanical sensors
 - 3D measurement
- latest development
 - cell phones and an application

Deceleration and Change in Speed

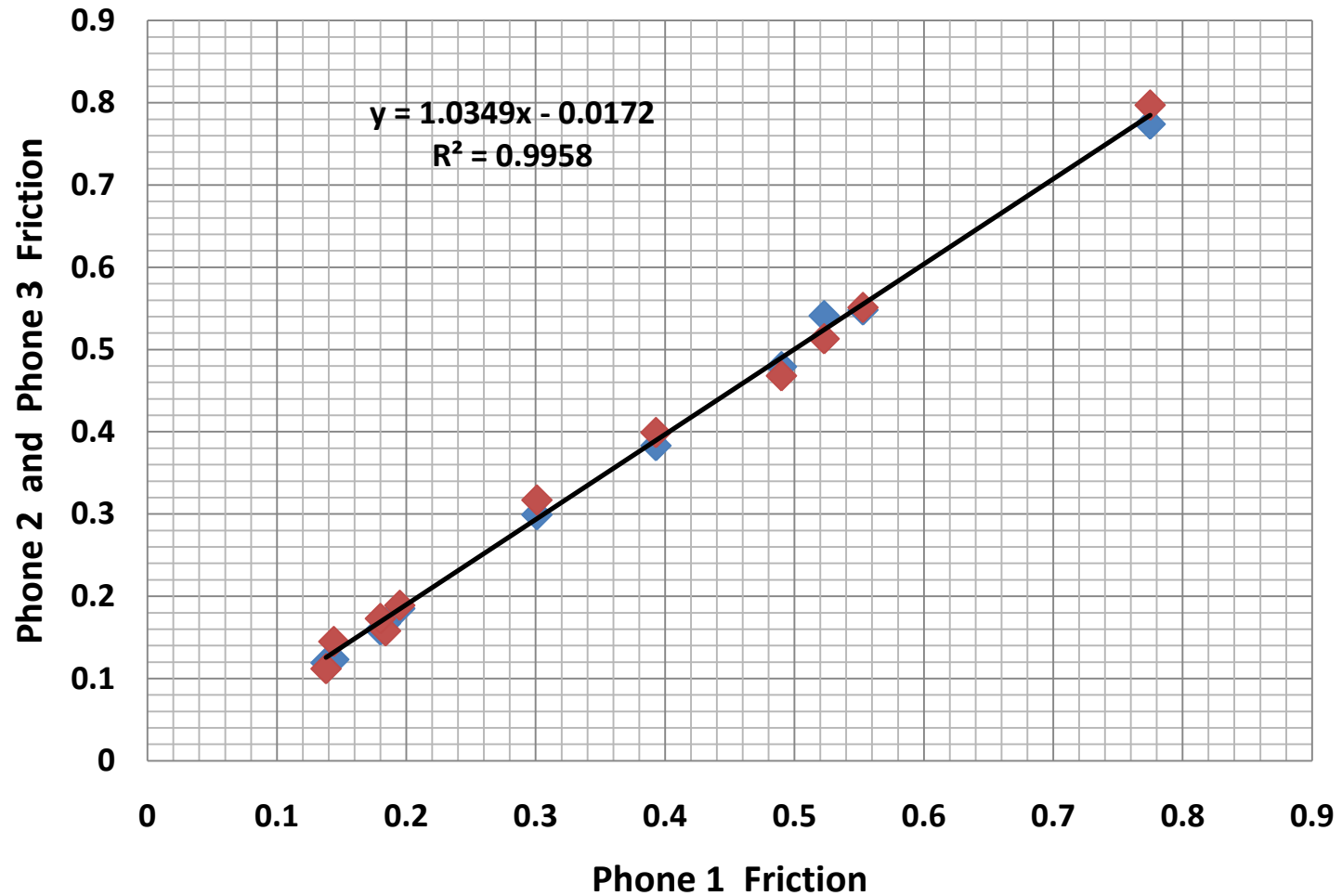


Cell Phone Friction Meters

- many modern cell phones have a 3D accelerometer → application
- advantages
 - communication, GPS, camera, voice
 - absolute calibration against gravity
 - easy to use: a few seconds and go!
 - very short braking is enough!
 - any position
 - vehicle independent
 - real time map interface to data



Comparing three different phones



Map interface to Mobile Friction Measurement System (M μ MS)

For details look at:

<http://www.liukasta.info>



Legend	
<input checked="" type="checkbox"/> Slippery, friction under 0.5	<input checked="" type="checkbox"/> New measurement
<input checked="" type="checkbox"/> Caution, friction between 0.5 and 0.6	<input checked="" type="checkbox"/> Expiring measurement
<input checked="" type="checkbox"/> Good conditions, friction over 0.6	<input checked="" type="checkbox"/> Old measurement
<input checked="" type="checkbox"/> Old measurements (more than 5 hours ago)	<input checked="" type="checkbox"/> Weather station
<input checked="" type="checkbox"/> Recent measurements (between 5 and 1 hours ago)	<input checked="" type="checkbox"/> Good friction
<input checked="" type="checkbox"/> Up to date measurements (less than 1 hours ago)	<input checked="" type="checkbox"/> Caution
	<input checked="" type="checkbox"/> Slippery

Conclusion

- Freezing of solutions
 - meaning of DFP
 - soft and hard ice
- Friction coefficient
 - an absolute measure of slippery surfaces
- Measuring friction
 - there are easy, reliable and cost effective ways to measure friction on highways