

# **Measurement of the speed of vehicles in Czech Republic**

## **Type Approval, Verification**



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**Legal velocity measurement of vehicles on roads in the Czech Republic has a long tradition.**

**The first microwave doppler radars have been used from the middle of last century. The production of Czech radars has also a similarly long tradition.**

**Czech Metrology Institute is responsible for type approval and for verification of all police speedometers**

**Measuring of velocity in Czech Republic  
is performed by the following speedometers (approx 500 pc):**

- 1) Microwave Doppler Radars (CW)
- 2) Laser speedometers (Lidars)
- 3) Sectional speedometers

Radar



Lidar



Sectional



According to Czech Law all police speedometers shall be

- type approved and periodically verified (every year)
- equipped with digital camera

MPE:  $\pm 3 \text{ km/h}$  ( $v \leq 100 \text{ km/h}$ ) or  $\pm 3 \%$  ( $v > 100 \text{ km/h}$ )



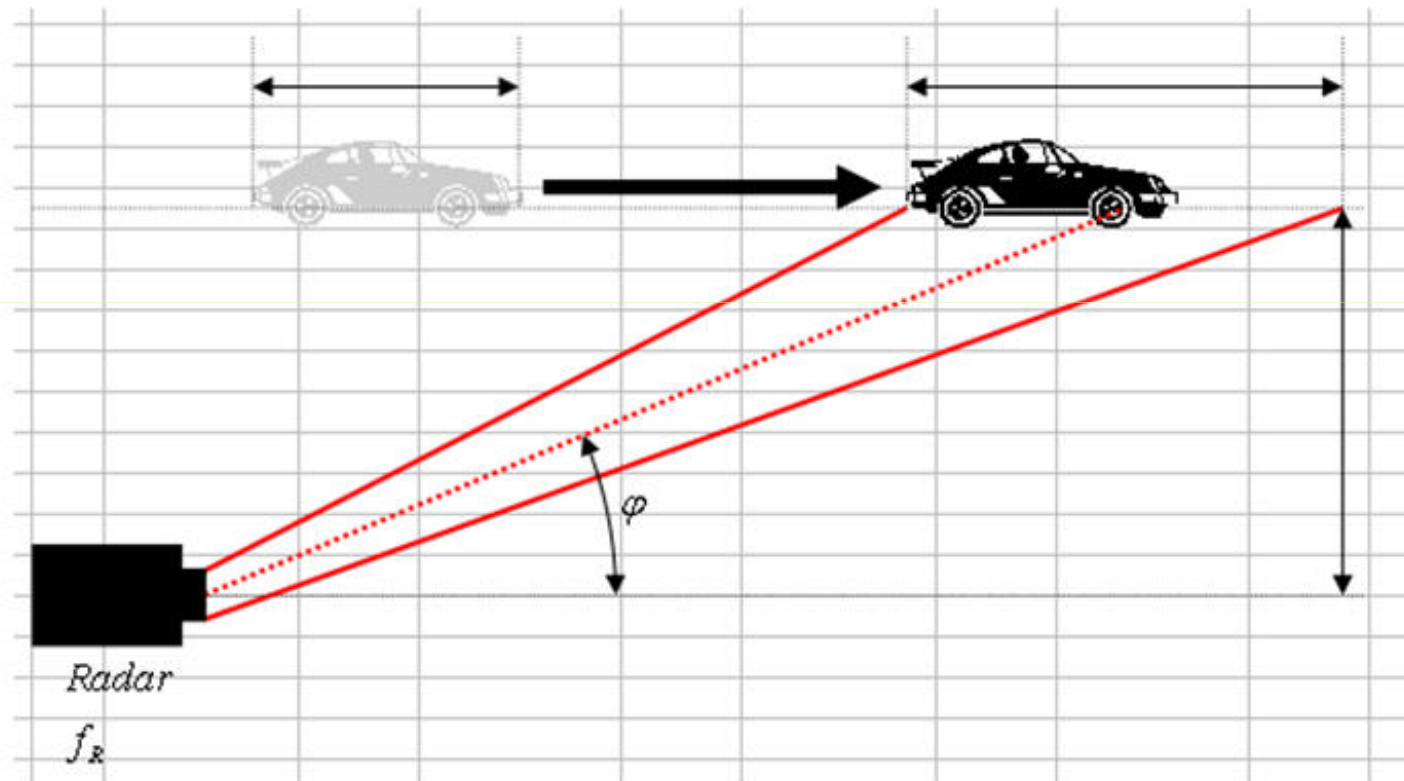


# The most used radars (CW)

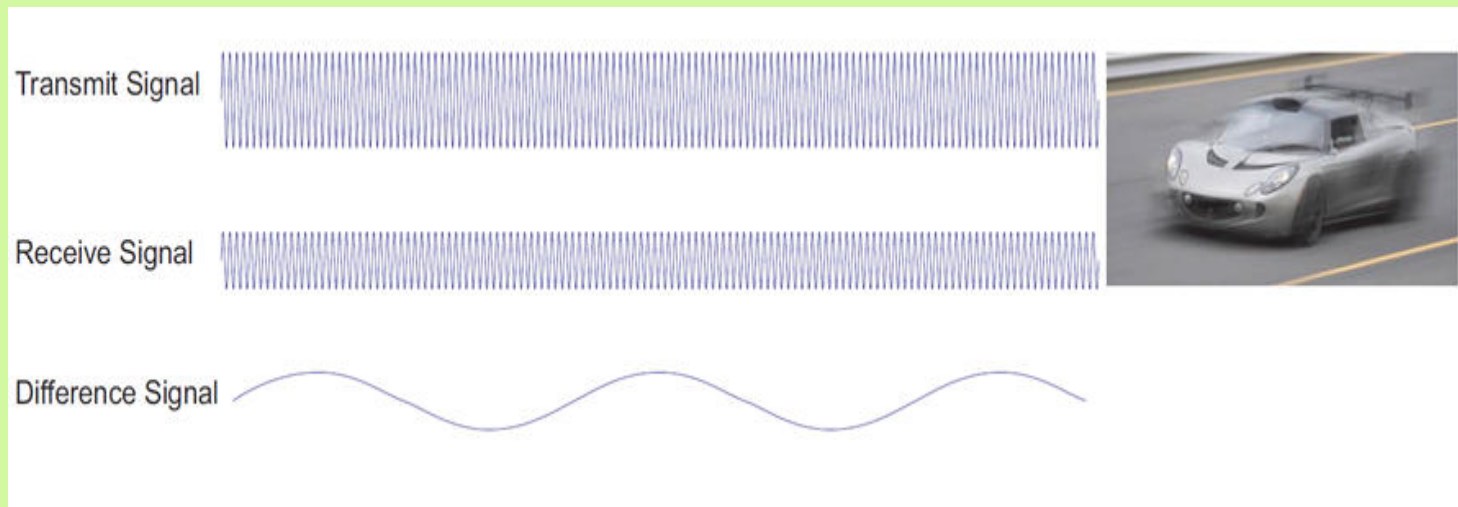


## CW Radar speed systems

### Measurement situation on the road



# Principle of microwave Doppler speedometer



Doppler shift:

$$f_d = \frac{2 v_r f_T}{c}$$

$f_d$  = Doppler shift frequency

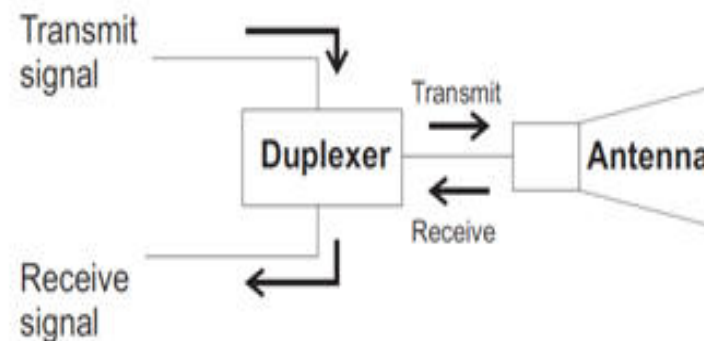
$v_r$  = relative velocity with respect to the radar

$f_T$  = transmitter frequency

$c$  = Velocity of propagation (speed of light)

**Single antenna with duplexer**

- Most common for down-the-road radars





## The rear of a white van is open, revealing a custom-built equipment rack. The rack holds a large rectangular light on the left, a white box with a circular lens in the center, and another large rectangular light on the right. A black metal frame supports these items. Below the rack, a silver metal toolbox sits on the floor. To the right of the toolbox is a cardboard box with a black arrow pointing upwards. A black bag is also visible on the floor. The van is parked on a paved surface next to a sidewalk and a building.

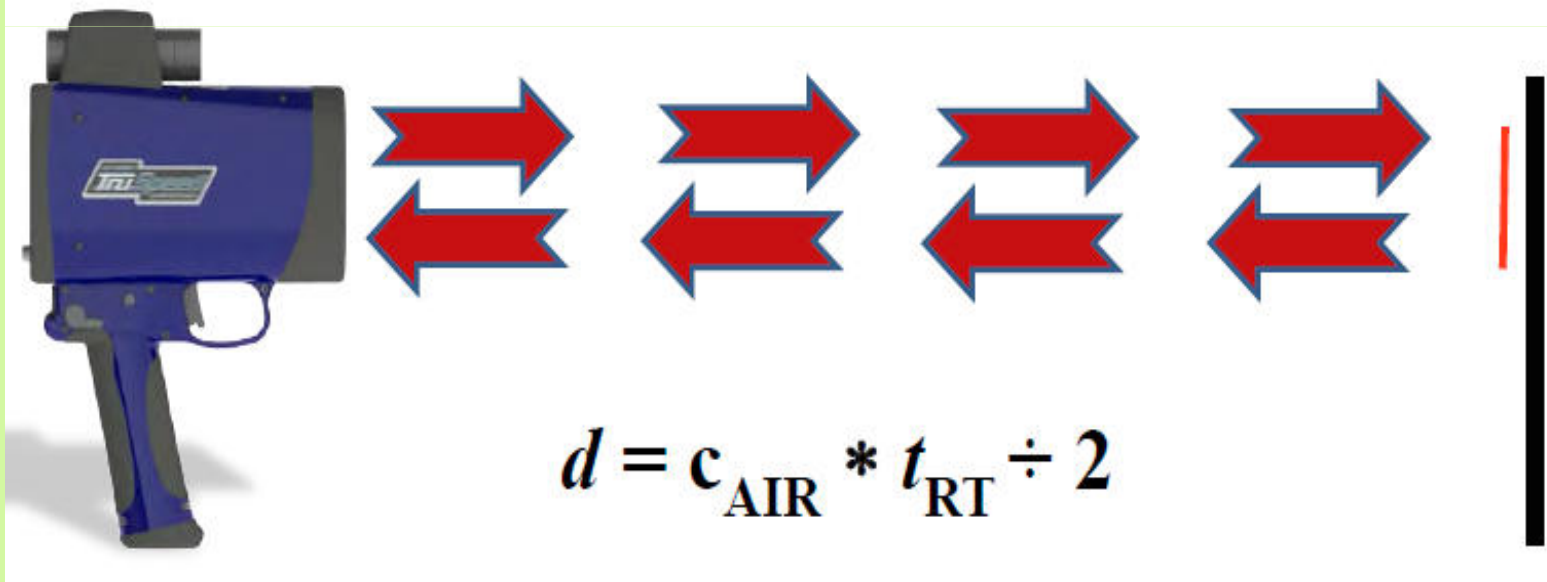




# Principle of lidar speedometer

The lidar device measures the time it takes the laser pulse to travel to and return from an object. Distance to the object is proportional to the time-of-flight of a laser pulse divided by two.

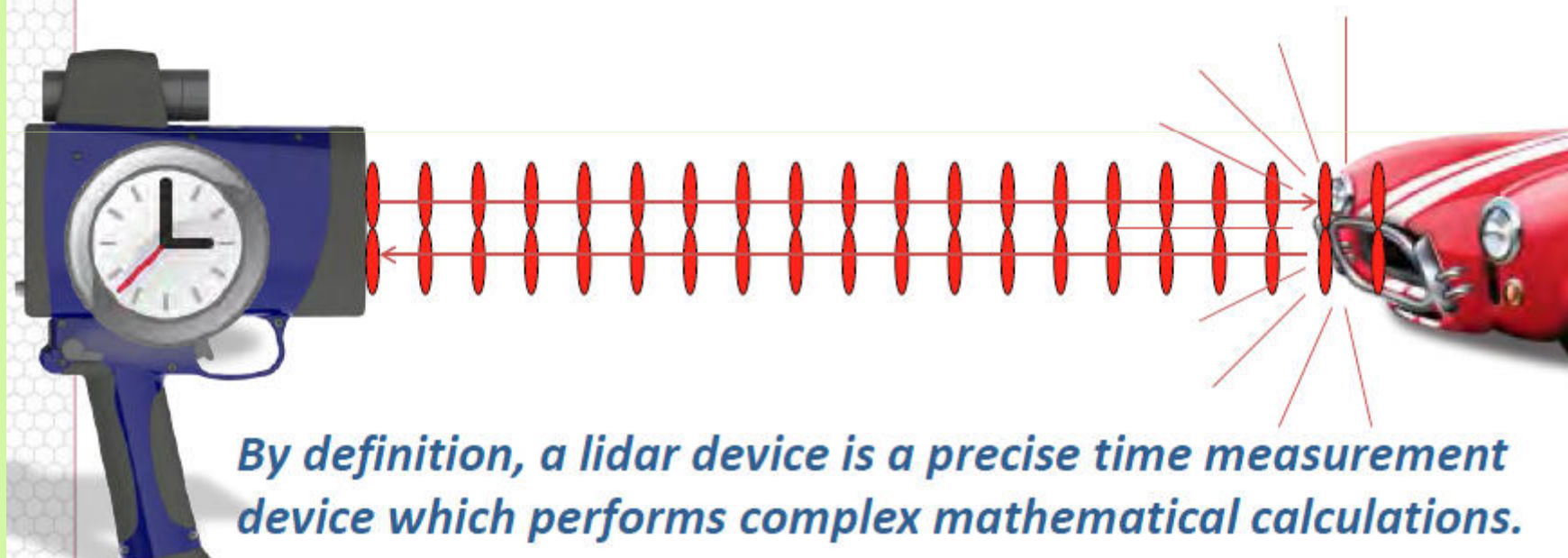
$$\text{Distance} = \text{velocity} * \text{time}$$



# Principle of lidar speedometer

A counter is started when the laser light is transmitted, and the counter is stopped when a portion of the signal is detected.

*One event (distance) per laser pulse*



LTI

- Principle of lidar speedometer

$$v = \frac{|d_1 - d_2|}{\Delta t}$$

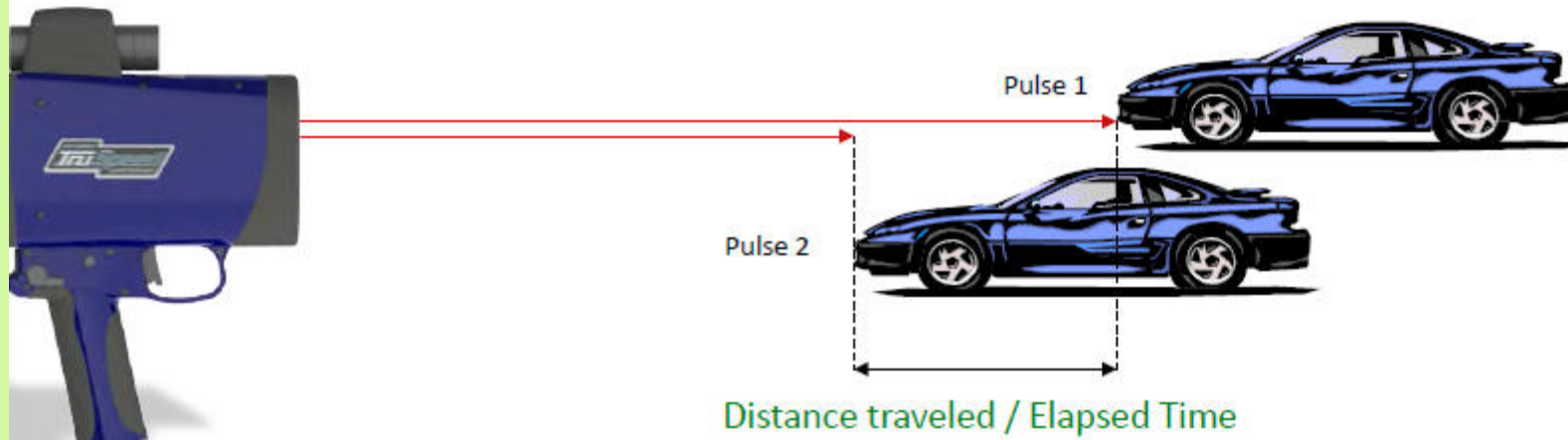
By sending out multiple pulses ( 2 or more ) we can calculate speed.

$\Delta d$  = quantitative change in distance

(distance change from pulse 1 and pulse 2)

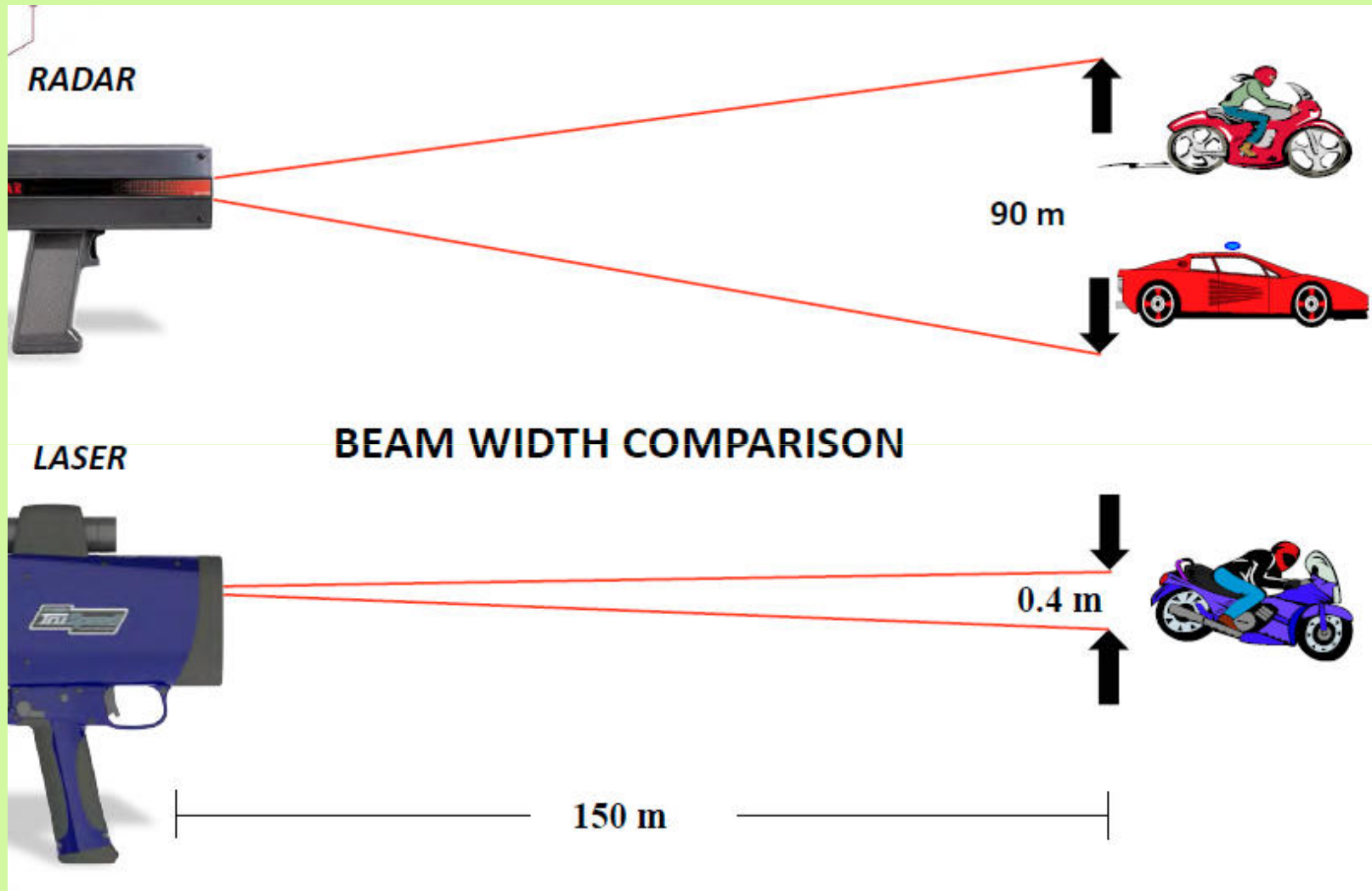
$\Delta t$  = quantitative change in time

(elapsed time from pulse 1 and pulse 2)



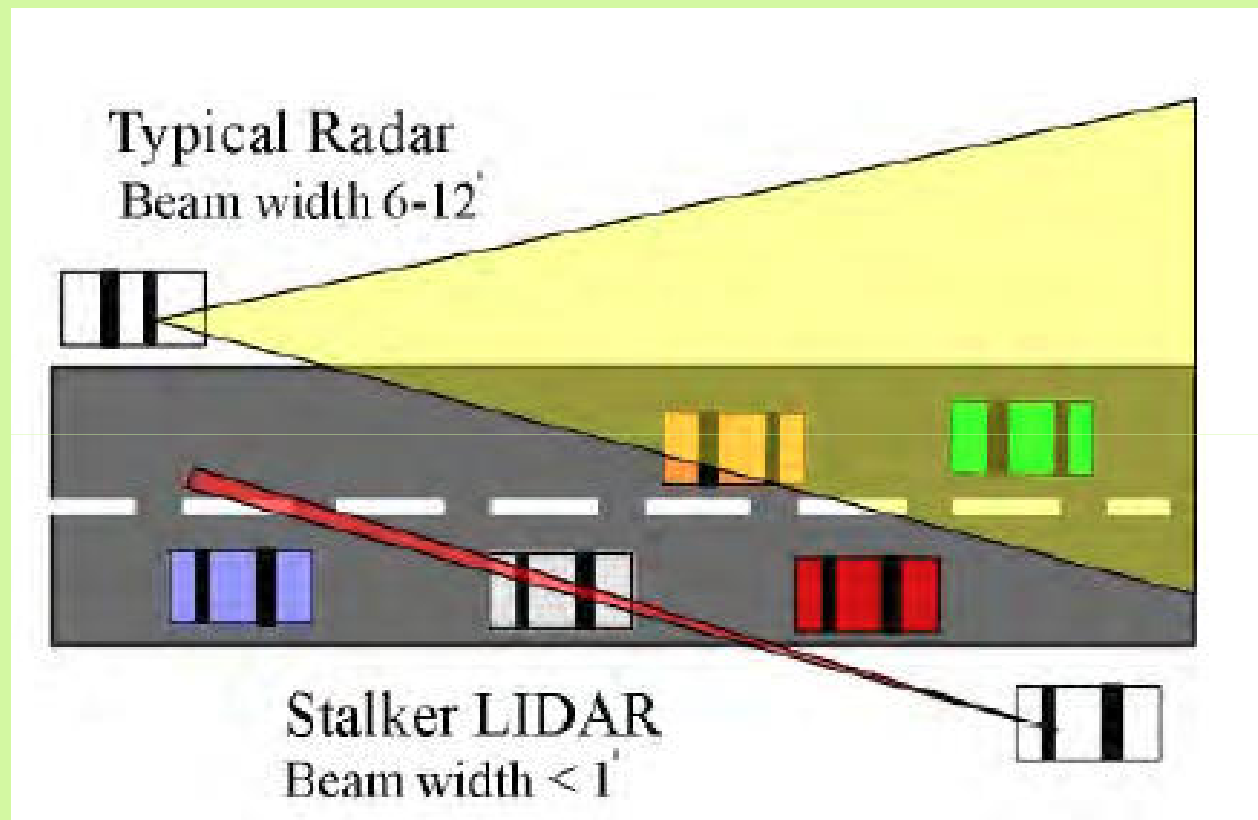
LTI

# TARGET DISCRIMINATION



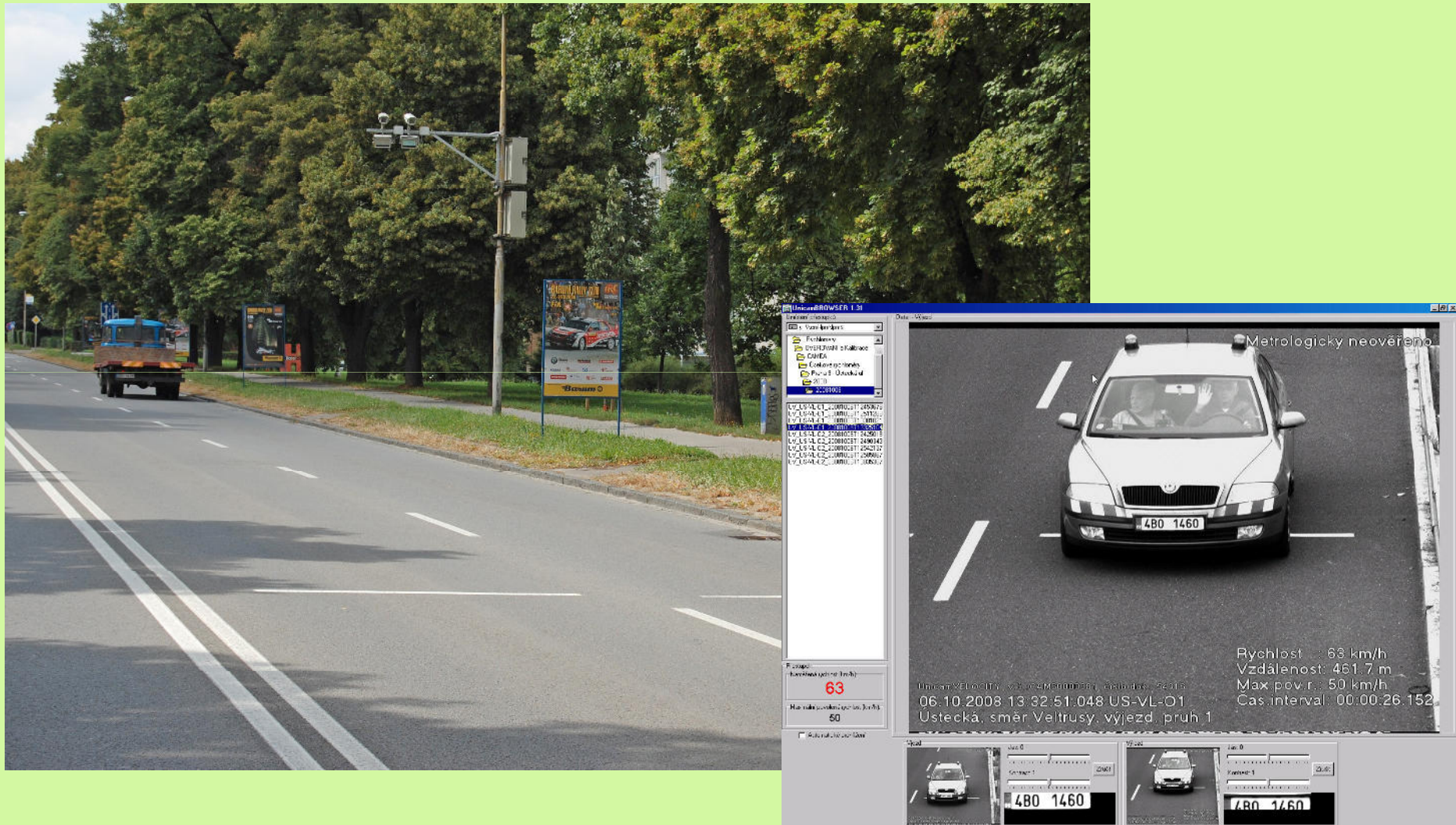


# TARGET DISCRIMINATION



LTI

# The most used automatic sectional speedometer with a long section measures average velocity





The sectional speedometer with a long section measures time of passage of measured car and calculates the average velocity

UnicamBROWSER 1.31

Umístění přestupků

Y: \\com-lpm\lpm\$

- \_Rychlomery
- OVEROVÁNÍ a Kalibrace
- CAMEA
- Úsekové rychlomery
- Praha 9 - Ústecká ul
- 2008
- 20081006

UV\_US-VL-01\_20081006T12453679  
UV\_US-VL-01\_20081006T12511269  
UV\_US-VL-01\_20081006T13301821  
**UV\_US-VL-01\_20081006T13365104**  
UV\_US-VL-02\_20081006T12425018  
UV\_US-VL-02\_20081006T12490343  
UV\_US-VL-02\_20081006T12542137  
UV\_US-VL-02\_20081006T12585867  
UV\_US-VL-02\_20081006T13035367

Přestupek

Naměřená rychlost (km/h):

**63**

Maximální povolená rychlost (km/h):

**50**

☐ Automatické prohlášení

Detail - Výjezd

Metrologicky neověřeno

Rychlost : 63 km/h  
Vzdálenost: 461.7 m  
Max.pov.r.: 50 km/h  
Cas.interval: 00:00:26.152

UnicamVELOCITY, v.6 :CAM60000681, číslo dok.: 54316  
06.10.2008 13:32:51.048 US-VL-01  
Ústecká, směr Veltrusy, výjezd, pruh 1

Vjezd

Jas: 0

Kontrast: 1

Zrušit

480 1460

Výjezd

Jas: 0

Kontrast: 1

Zrušit

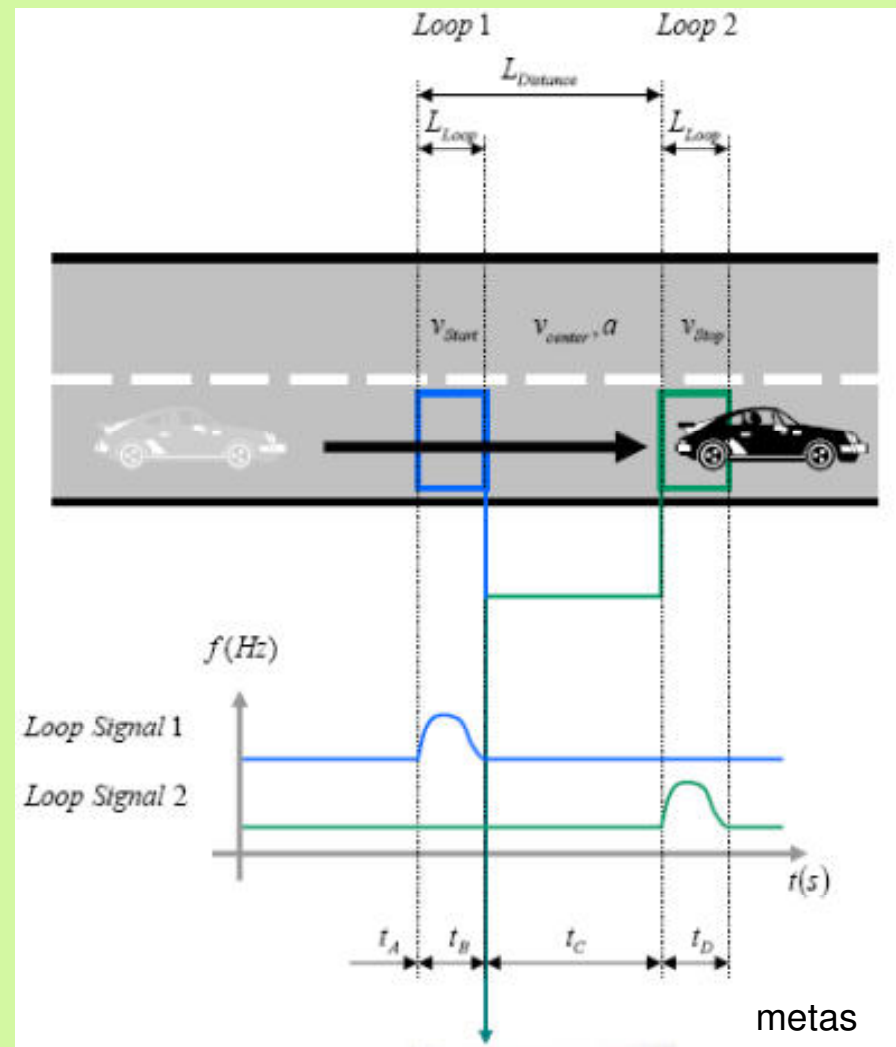
480 1460

The most used sectional speedometer with a short section and inductive loops measures immediate velocity





# Inductive loop detectors



# Type approval of speedometers

- **Metrological tests (OIML R91, WELMEC, Czech law, Ordinances):**
  - Laboratory tests (incl. SW)
  - Field tests (MPE)
- **Environmental tests (OIML D11, ISO):**
  - Vibration,
  - Climatic tests: e.g Dry static heat, Static Cold, Damp heat static, Damp cyclic, Impacting water, Dust
- **EMC tests (OIML D11, ISO):**
  - Electromagnetic and magnetic fields,
  - Burst, Surge, Injection, discharge,
  - Automotive Transient

# Type approval of speedometers

Metrological tests according OIML R91, Czech Law and Ordinances :

- **In the laboratory:**

e.g. RADAR:

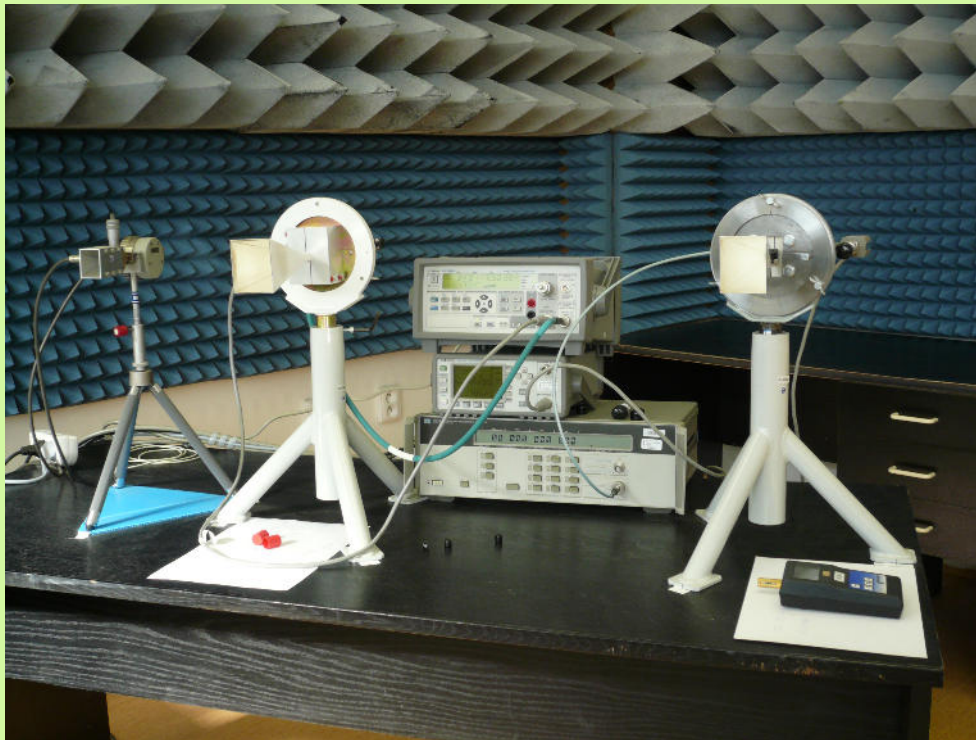
Antenna radiation pattern, microwave frequency stability, power limitation....

- **In the field:**

500 measurements shall be made, of which none shall give a positive error larger than + 3 km/h (or + 3 % at speeds above 100 km/h). All errors of indication shall be less than  $\pm 1$  km/h, or  $\pm 1$  % at speeds above 100 km/h.

# Type approval of speedometers

In laboratory: Radar antenna radiation pattern, microwave frequency stability, power limitation



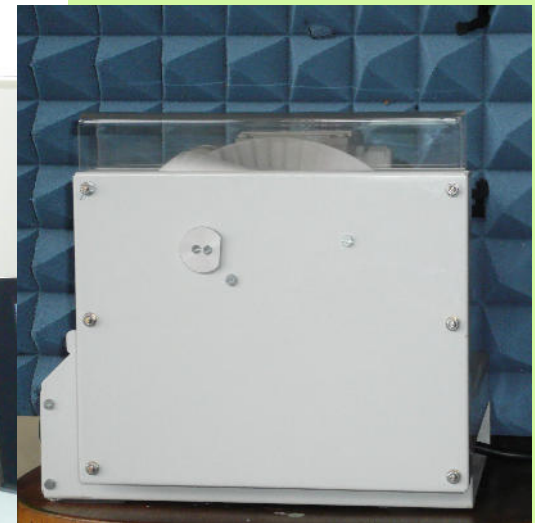


# Type approval of speedometers

Environmental tests - temperature, humidity



Simulator  
(one speed)



# Type approval of speedometers

Environmental tests - vibration (random and sinusoidal)





# Type approval of speedometers

EMC Tests:

Electrostatic Discharge

Automotive Transients



# Type approval and verification test

Speed comparison on the road (motorway)

**Disadvantages of a comparison on the road**

Speed limits (depends on road category)

The number of vehicles per vehicle categories are random

Time intense and depends on the climatic situation

Sometimes difficult at dense traffic condition

The time is coming when tests on the road  
are simulated in the laboratory

metas



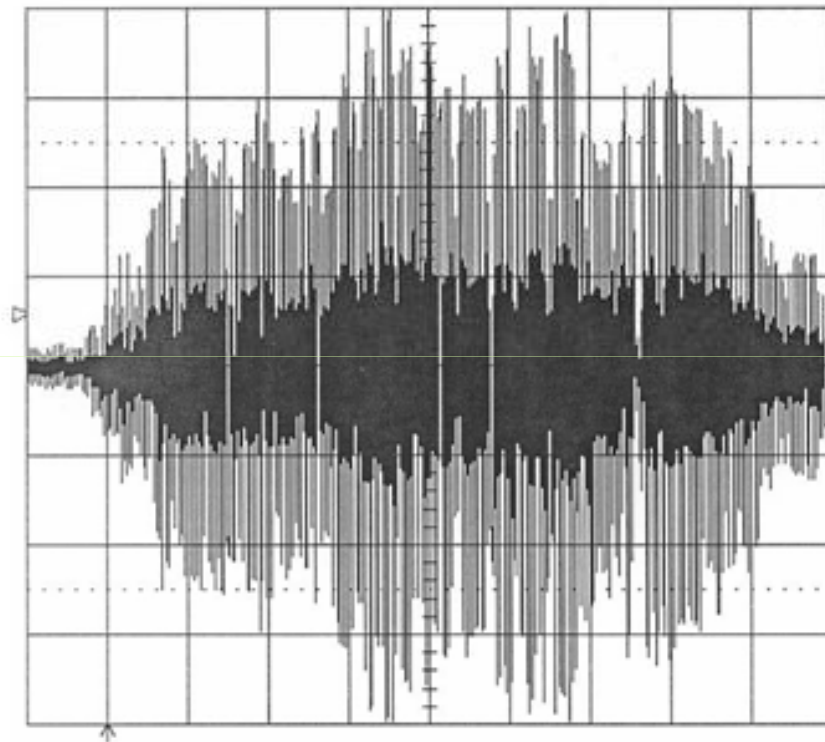
# Periodical verification of speedometers in the laboratory

## LIDAR – Simulator e.g. LTI model LSMS

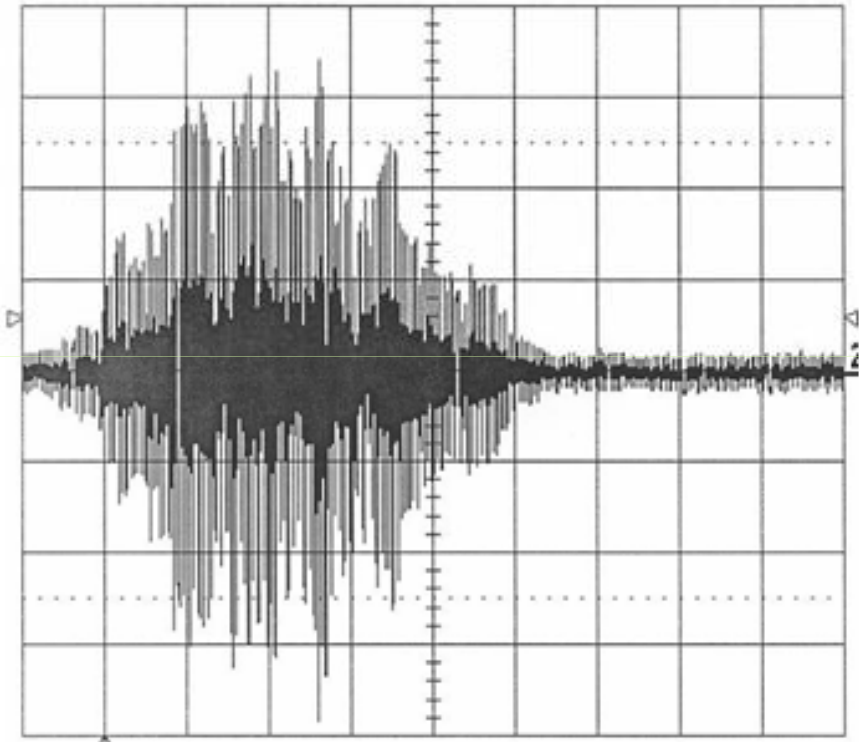


## Doppler signals from different vehicles (road)

**Doppler signal, simple car**



**Doppler signal, Motorcycle**



metas



# Periodical verification of speedometers in the laboratory

RADAR simulator Ramet VFM

Recording of the real Doppler signals from moving vehicles



# Periodical verification of speedometers in the laboratory

RADAR simulator Ramet VFM - Solution For Fixed Radar Speed Cameras





# Periodical verification of speedometers in the laboratory

RADAR simulator Ramet VFM - Solution For Vehicle-Built-In Radar Speed Cameras





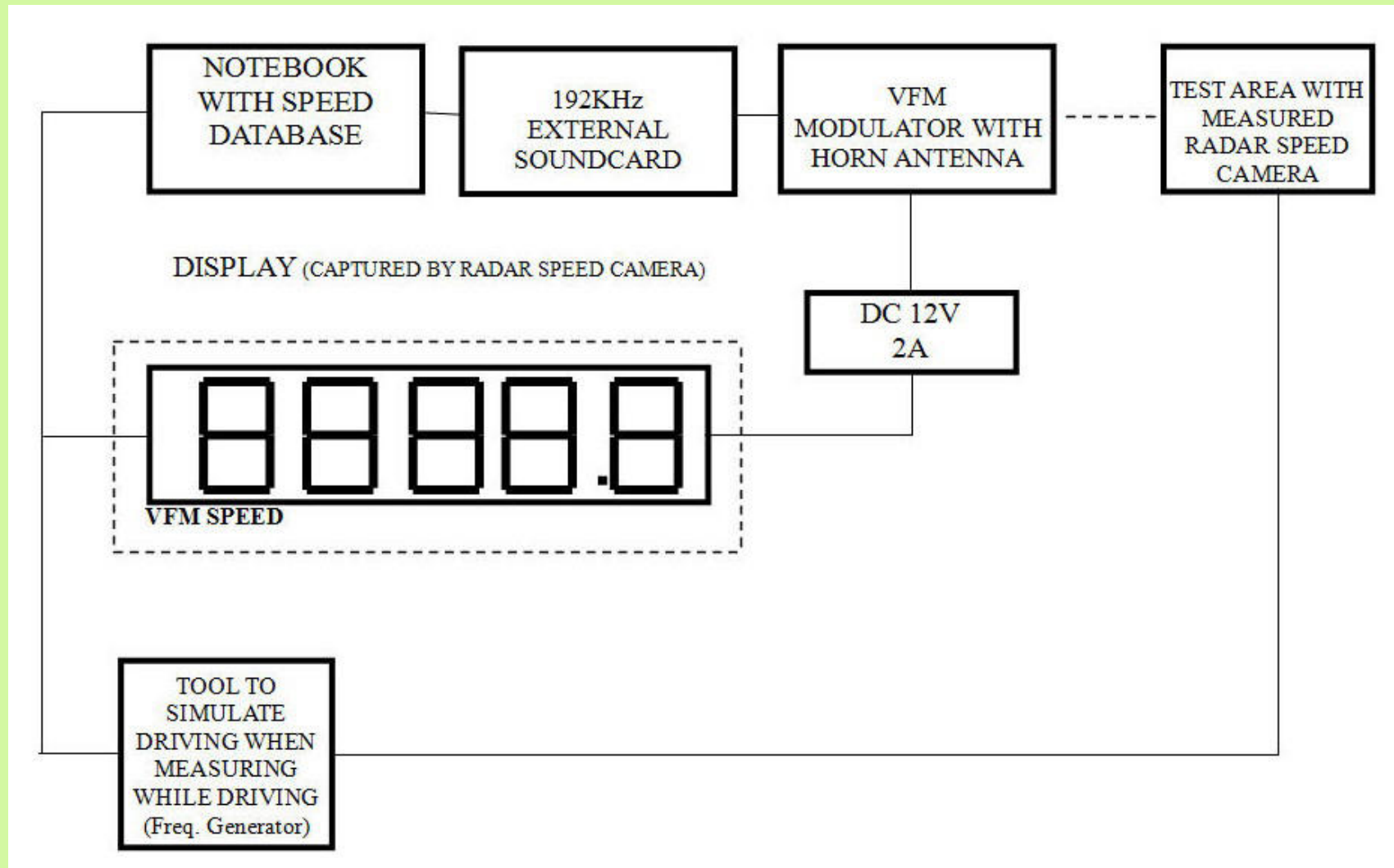
# Periodical verification of speedometers in the laboratory

RADAR simulator Ramet VFM - Solution For Vehicle-Built-In Radar Speed Cameras



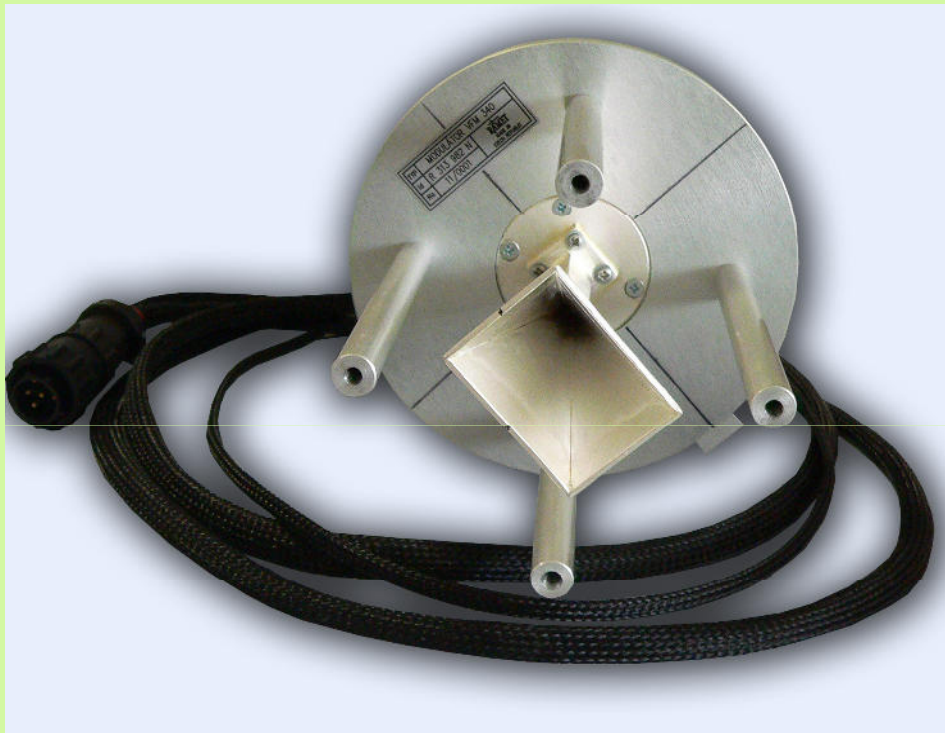
# Periodical verification of speedometers in the laboratory

## RADAR simulator Ramet VFM - Block Diagram

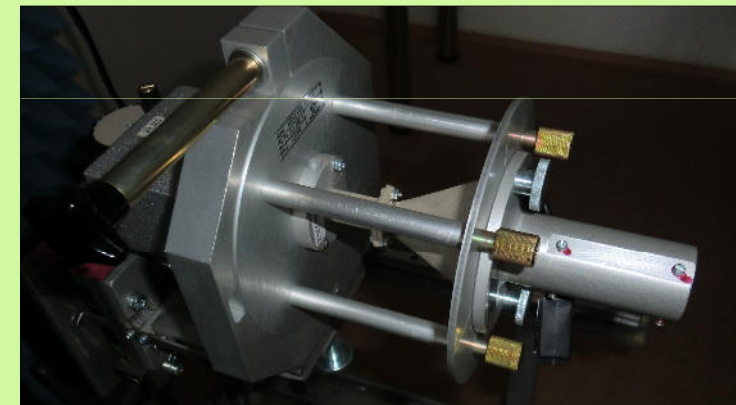


# Periodical verification of speedometers in the laboratory

## RADAR simulator Ramet VFM - modulator



**3 different modulators (24,125 GHz, 34,0 GHz and 34,3 GHz)**

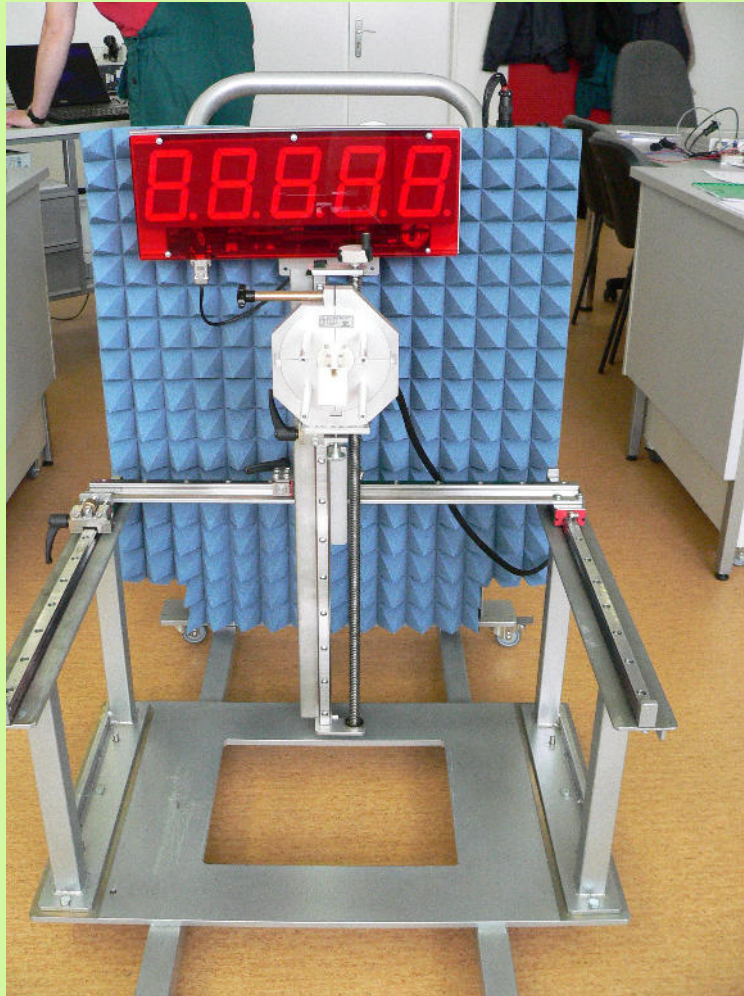


**Laser point aiming tool and its mounting onto the modulator**



# Periodical verification of speedometers in the laboratory

## RADAR simulator Ramet VFM



When performing the speed simulation, the display will show the simulated speeds and also measured direction

A – approaching vehicle

D – departing vehicle



# Periodical verification of speedometers in the laboratory

## RADAR simulator Ramet VFM



Example of an image taken by RAMER10 C radar speed camera (equipped with monochromatic camera), while being tested on the VFM Simulator

# Periodical verification of speedometers in the field

Test vehicle CMI with standard speedometer





# Periodical verification of speedometers in the field

## Standard speedometer CMI

(5 km/h – 250 km/h, Uncertainty 0,2 km/h)



Standard speedometer CMI is connected to CAN bus in the test vehicle and is automatically calibrated by GPS speedometer SAT 1 - so it is not necessary to measure the pressure in tyres



SAT100 receiver with integrated speed display, gooseneck holder and suction cup

# Standard speedometer CMI - interlaboratory comparison

Interlaboratory comparison of the standard speedometers was performed in 2011 between

**CMI** (Czech Metrology Institute, Prague, Czech Republic) and

**BEV** (Federal Office of Metrology and Surveying, Vienna, Austria).

The comparison was organised by BEV at October 2011. The results was evaluated according to EN ISO/IEC 17043:2010.

## Used equipments

### BEV

The new standard speedometer of the BEV is a time-over-distance system, using pressure sensitive cables (Piezo sensors) and a self developed measuring unit. It is installed at the highway A1 near Vienna.

The system works with 3 sensors per lane, the distance between the sensors is 4 m each. The estimated measurement uncertainty was 0,3 %. A camera is connected to the speedometer and it is taking one picture of each measured car. In this way it is easy to compare measurements from the standard speedometer and other speed measuring instruments.

### CMI

The standard speedometer CAMEA Model Unicam VELOCITY 3 is installed in the measuring car and it receives information about the speed of measuring car via CAN-bus. The standard speedometer is automatically calibrated by GPS speedometer PEGASEM model SAT 100. The estimated measurement uncertainty was 0,2 km/h.



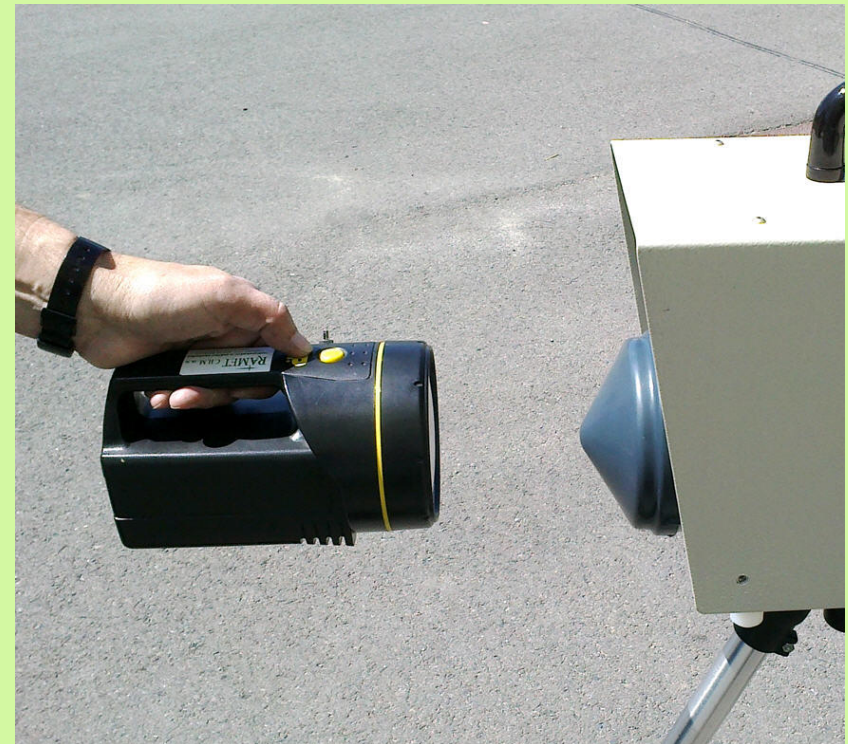
# Standard speedometer CMI - interlaboratory comparison



Result of the interlaboratory comparison



## Precise battery operated Simulator RAMER VF for outdoor Testing of Radar Function





## Precise battery operated Simulator RAMER VF for outdoor Testing of Radar Function



*Table of simulated speeds:*

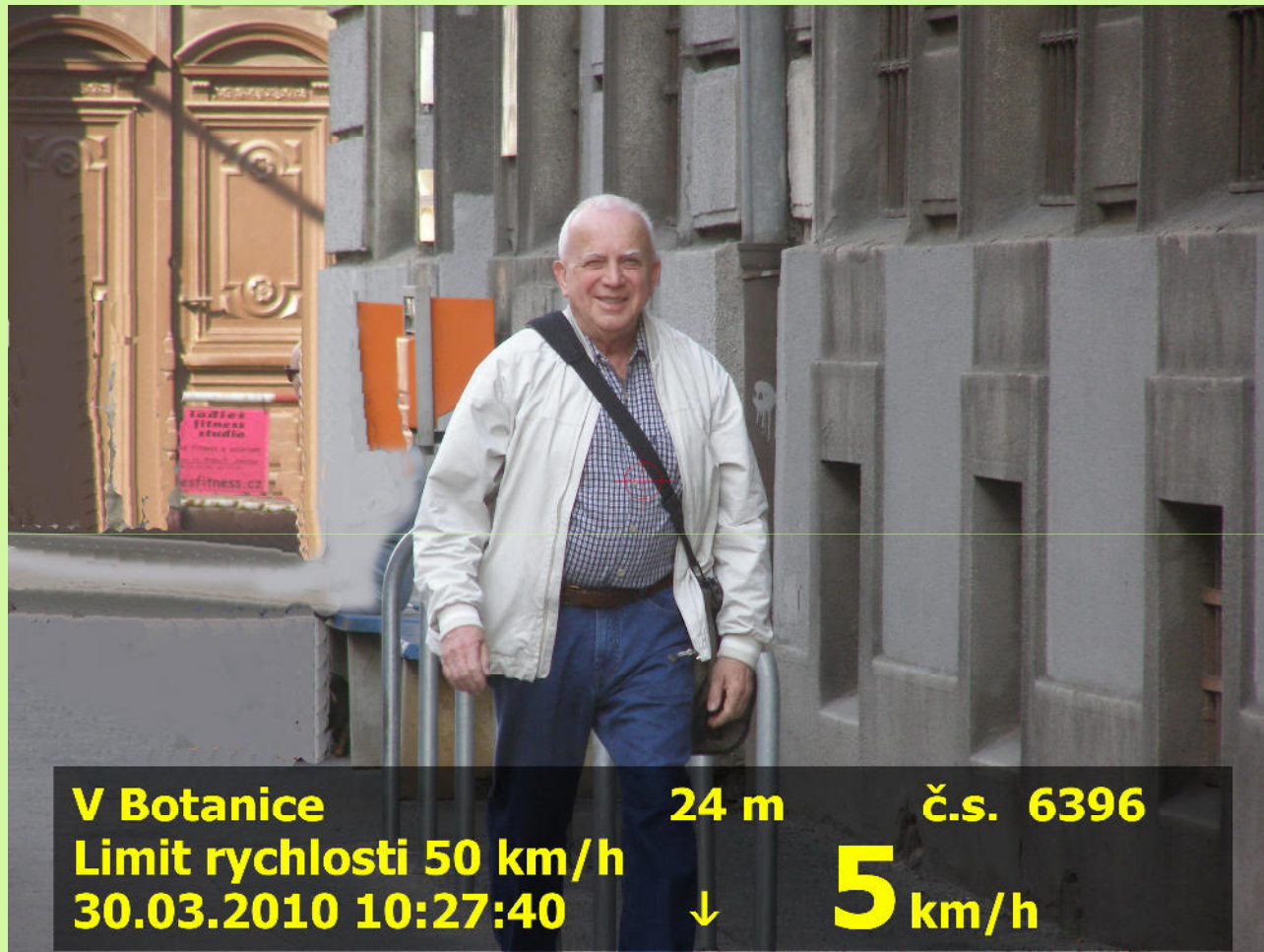
VF340 (34,00GHz)		VF343 (34,30GHz)		VF241 (24,125 GHz)	
Departing (km/h)	Approaching (km/h)	Departing (km/h)	Approaching (km/h)	Departing (km/h)	Approaching (km/h)
Speed / Displayed	Speed / Displayed	Speed / Displayed	Speed / Displayed	Speed / Displayed	Speed / Displayed
207.46/ <b>207</b>	203.35/ <b>203</b>	205.66/ <b>205</b>	201.58/ <b>201</b>	233.92/ <b>233</b>	229.28/ <b>229</b>
103.73/ <b>103</b>	101.68/ <b>101</b>	102.83/ <b>102</b>	100.79/ <b>100</b>	116.96/ <b>116</b>	114.64/ <b>114</b>
51.87/ <b>51</b>	50.84/ <b>50</b>	51.41/ <b>51</b>	50.39/ <b>50</b>	58.48/ <b>58</b>	57.32/ <b>57</b>
25.93/ <b>25</b>	25.42/ <b>25</b>	25.71/ <b>25</b>	25.20/ <b>25</b>	29.24/ <b>29</b>	28.66/ <b>28</b>

# What is needed now?

- International recommendation OIML R91-1990 is now 24 years old and does not include today speed measuring technology (lidars, automatic camera systems...) and testing by simulators.
- So we need urgently prepare amendment to OIML R91 which will cover also the present speed measuring technique and testing technologies.



# Thanks for your attention!



Author's speed measured by lidar