



RETROREFLECTION MEASUREMENTS - QUALITY ASSURANCE AND ACCEPTANCE TESTS IN FINLAND

NORDISK VEJAFMÆRKNINGSKONFERENCE

7.2.1018

JAAKKO DIETRICH

RAMBOLL

CONTENT

- Retroreflection measurements in Finland
- Foundations for quality assurance
- Acceptance test – test procedures
- Test results - observed quality
- Critical points in quality assurance

RETROREFLECTION MEASUREMENTS IN FINLAND

- Retroreflection measurements are in a key role in the contracts
- Contractors provide the measurements
- 4 mobile measurement devices
 - All devices are made by Delta
- 10 hand-held device, 9 Delta, 1 Potters
- Reproducibility, repeatability and correct, traceable calibration are essential!



FOUNDATIONS FOR QUALITY ASSURANCE

SFS EN 1436

- Measurement geometry

1

Quality requirements

- Acceptance test
- General requirements for the devices, maintenance and quality assurance

2

Method description

- How to measure and report the results
- How to handle exceptions

To be published 2018

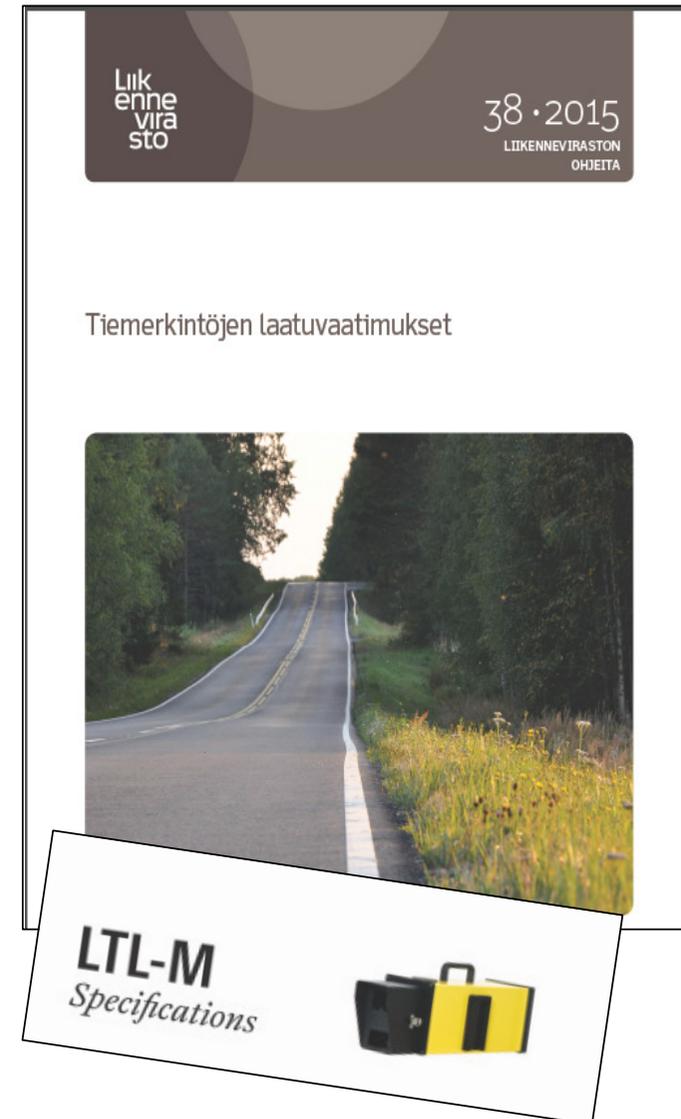
3

A user guides by the device manufacturer

- Maintenance instructions
- Calibration
- Measurement conditions

4

RAMBOLL



ACCEPTANCE TEST

- All devices used in quality control in state owned roads have to pass the acceptance test
- Organised yearly in May, just before the measurement season
- Tests are done during a day
- Mobile and hand-held devices are tested at the same time
- Evidence for yearly maintenance and calibration required before the test
- Calibration blocks of the hand-held devices tested and measured by Aalto University
- Measurement "licence" is valid until the next test



TEST SETUP

MOBILE DEVICES

- 10 road sections
- Total length 35 km
- With repetitions ~90 km
- Value range from 80 to 200
- 10 cm and 20 cm wide markings
- Starting points marked on the pavement
- No time limit for the measurements
- Possibility to
 - Clean the lenses carefully
 - Check the data before the delivery
- Data is delivered on site

Test setup in 2017

Section	Length (m)	Repeats
1	700	5
2	300	5
3	800	5
4	1600	5
5	1600	5
6	3800	2
7	3800	2
8	4300	2
9	4300	2
10	15000	2



TEST SETUP

MOBILE DEVICES

Short sections with 5 repetitions

- Repeatability
(comparison with hand-held devices)

Longer sections

- Correlation with other devices
- Bias
- (Linearity)
- Performance in production mode

Test setup in 2017

Section	Length (m)	Repeats
1	700	5
2	300	5
3	800	5
4	1600	5
5	1600	5
6	3800	2
7	3800	2
8	4300	2
9	4300	2
10	15000	2



TEST SETUP

HAND-HELD DEVICES

- Calibration blocks and the condition of the devices is checked prior the test on site
- 3 – 4 homogeneous, 100 m long test sections
- Value range 60 - 250
- 100 measurements are taken from each section
- Measurement points are painted on the pavement
- The value of the calibration block is measured in the end of the day
 - stability
- No repetitions, no test panels/boards



TEST CRITERIA

MOBILE DEVICES

- Repeatability < 5 %
- Systematic difference between devices < 10 %
- Performance in production mode
 - correlation, section averages, standard deviation, outliers
 - ability to report values in required format

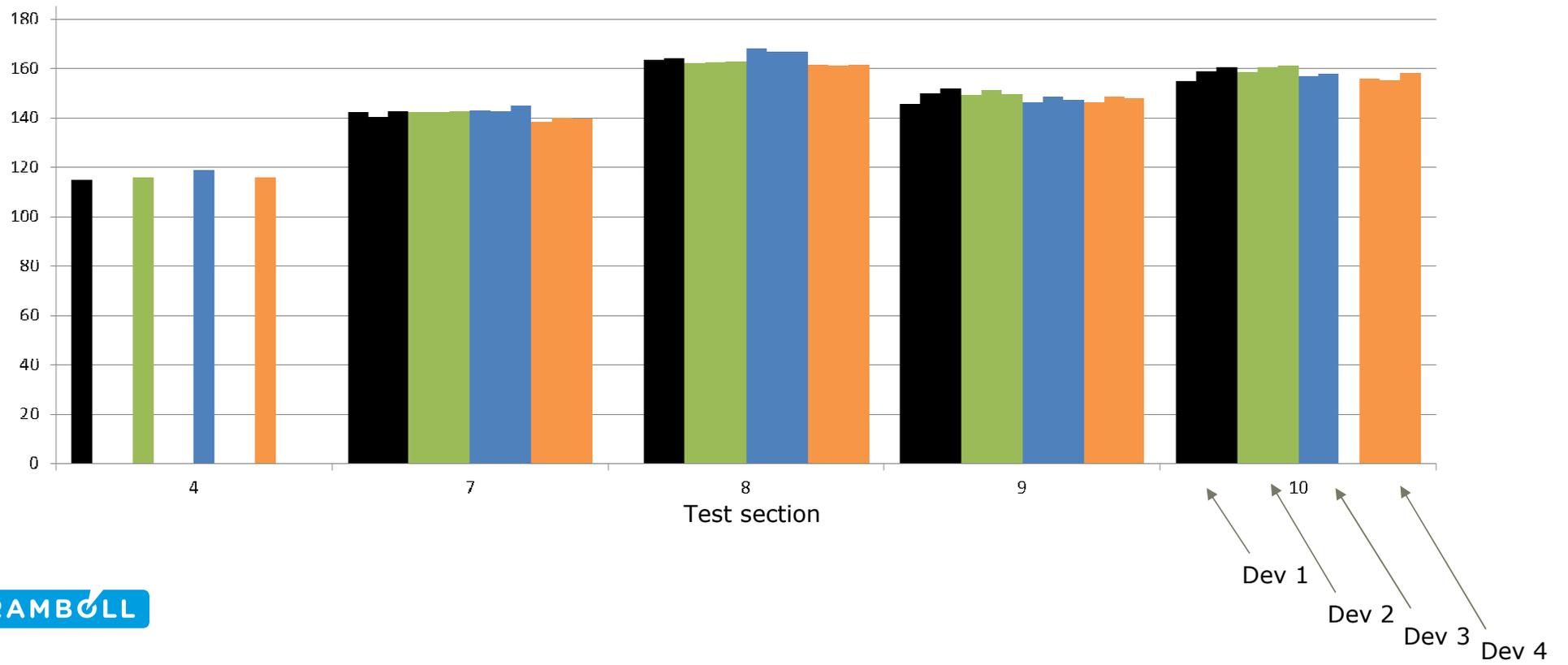
(Difference between mobile and hand-held devices)

HAND-HELD DEVICES

- Systematic difference < 8%
- Stability (< 4 units in a day / trend)
- Overall performance
 - correlation, section averages, spikes, outliers

RESULTS - MOBILE DEVICES 2017

AVERAGES BY SECTIONS



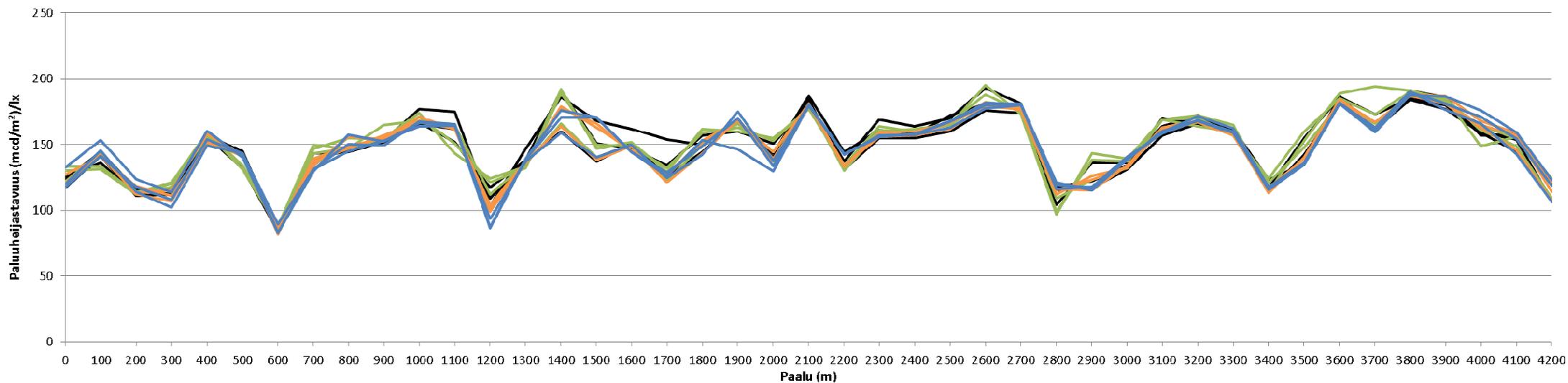
RESULTS - MOBILE DEVICES 2017

CORRELATION

Corr	Dev 1	Dev 2	Dev 3	Dev 4
Dev 1	0,96			
Dev 2	0,97	0,95		
Dev 3	0,97	0,96	0,97	
Dev 4	0,92	0,92	0,96	0,97

- Correlation between devices over 0,92
- At section level correlations typically over 0,90 ranging from 0,88 to 0,99

N = 2 x 162
Average retroreflectivity = 153



RESULTS - MOBILE DEVICES 2017

REPEATABILITY

Device	Rep.	Rep %
1	4,5	2,9 %
2	4,7	3,1 %
3	3,6	2,4 %
4	3,1	2,1 %
Average	4,0	2,6 %



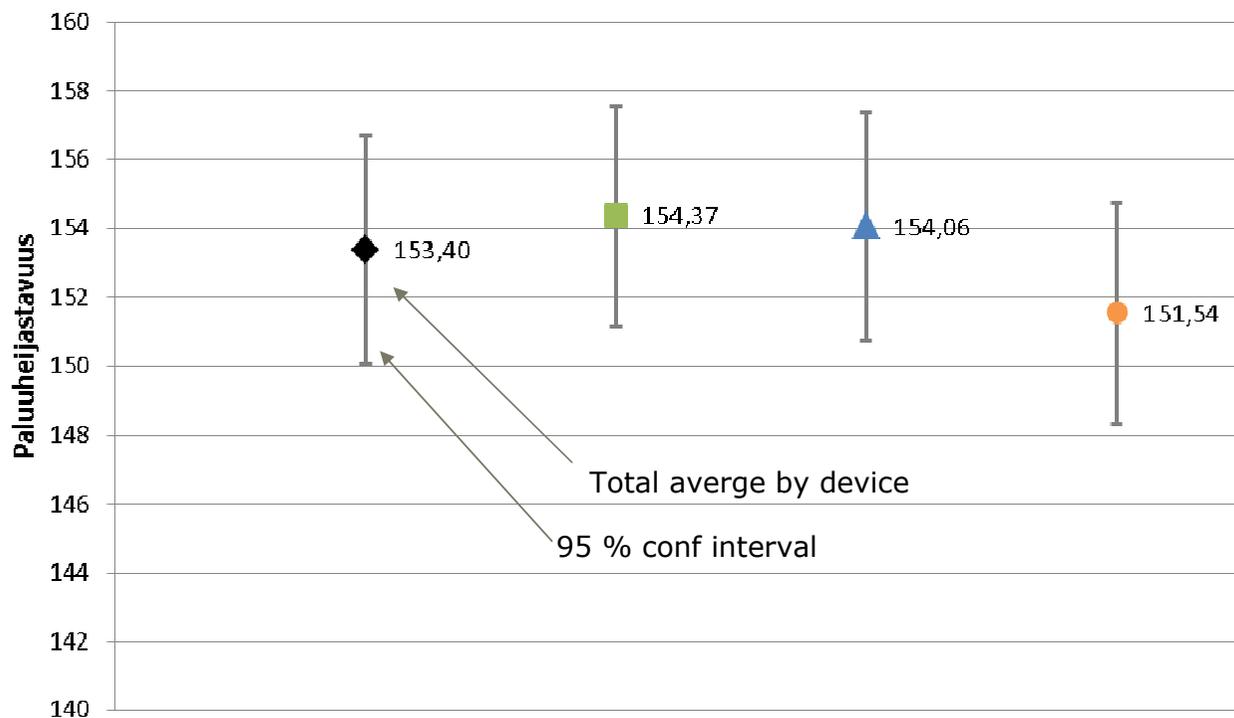
- Repeatability on average 2,6 %
- At section level repeatability 1,3 – 5,0%
- Four test sections
- N = 162
- Average retroreflectivity = 153

(According to Delta repeatability 3 – 5 %)

$$e_{rep} = \frac{1}{n} \sum_{i=1}^n \frac{|R_{i1} - R_{i2}|}{R_{i2}}$$

RESULTS - MOBILE DEVICES 2017

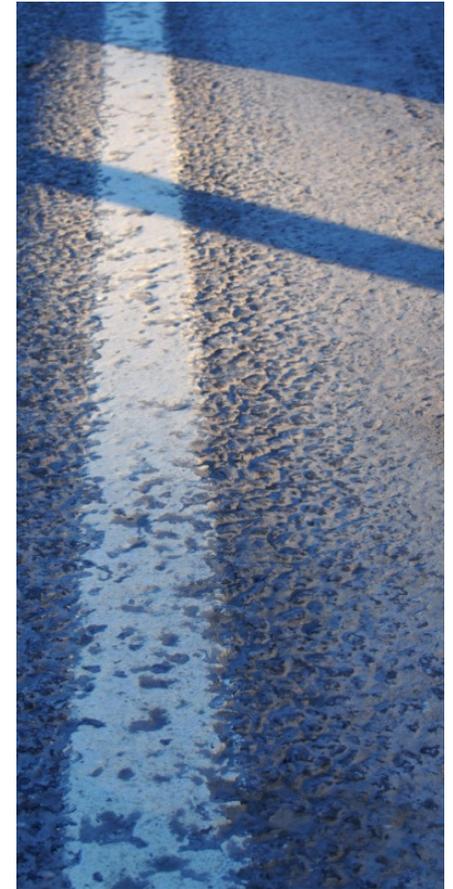
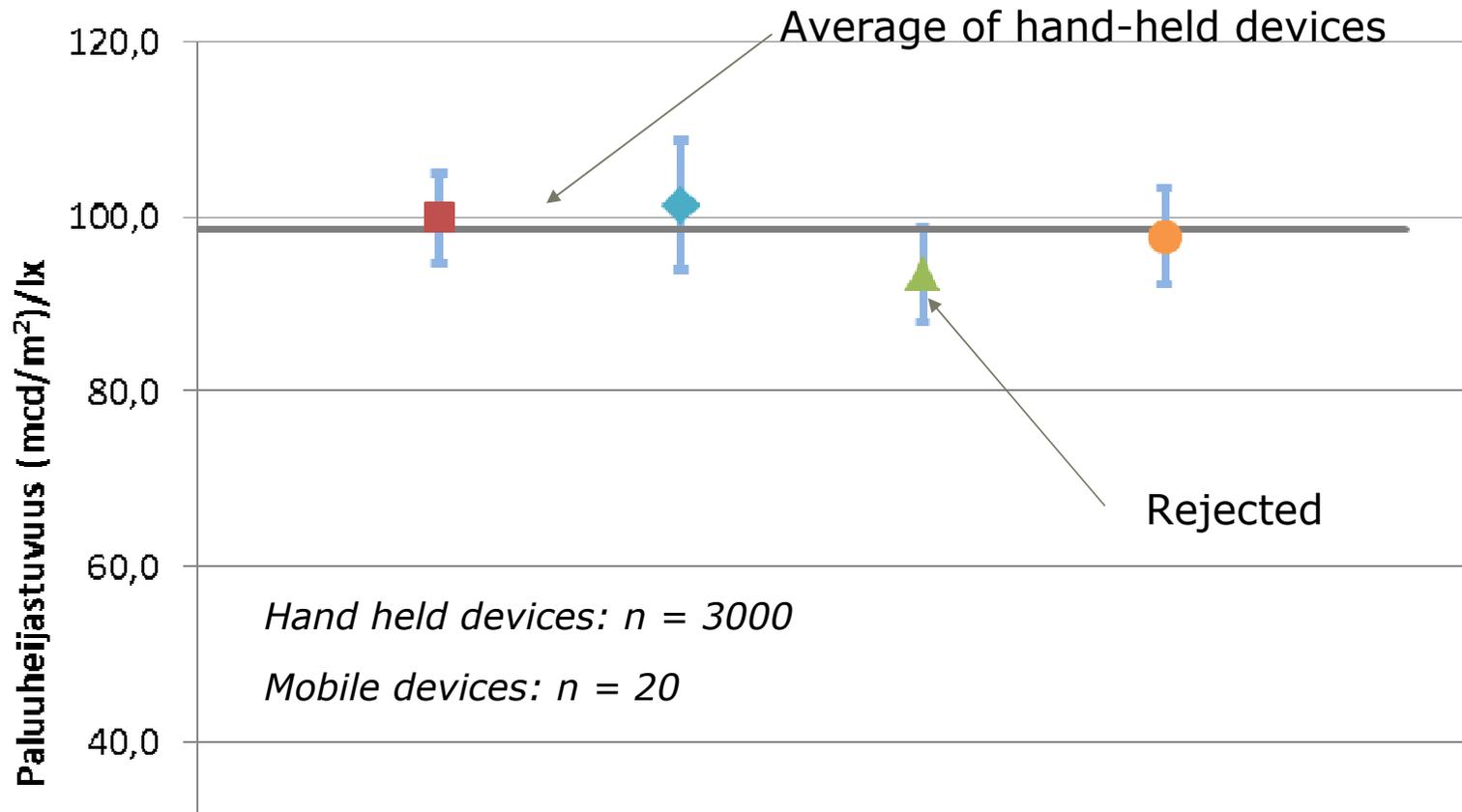
DIFFERENCES IN TOTAL AVERAGES



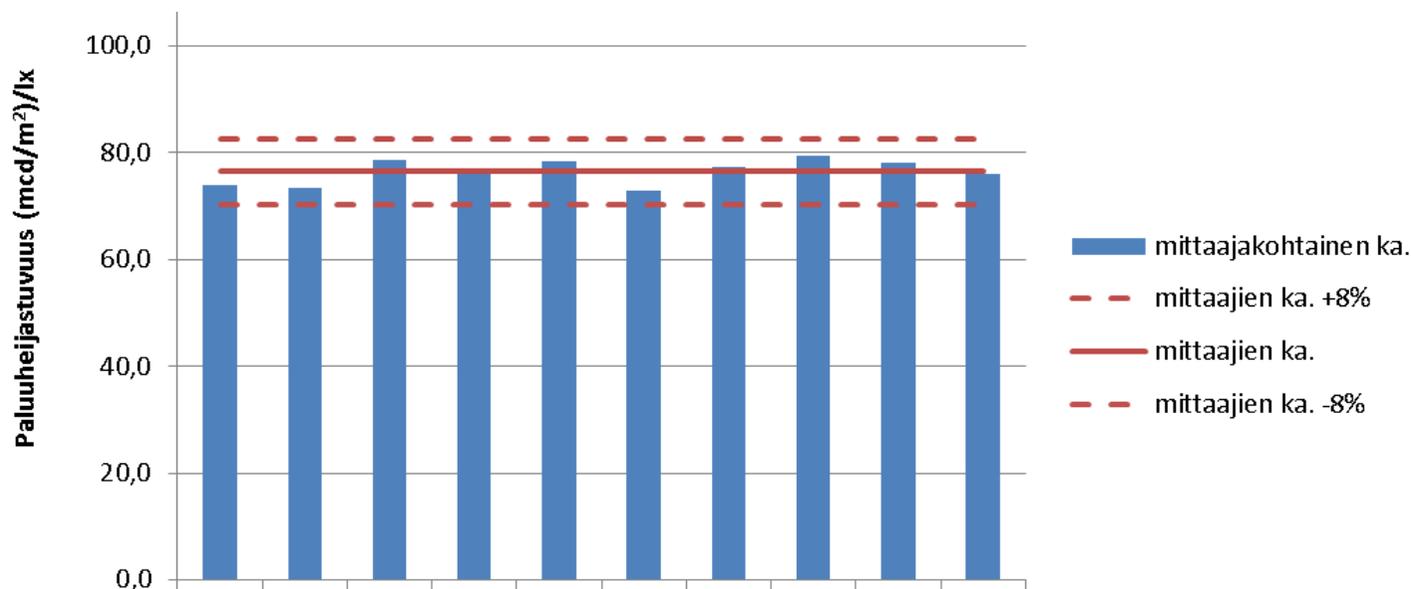
- No significant difference between the devices



MOBILE VS HAND-HELD DEVICES (2016)



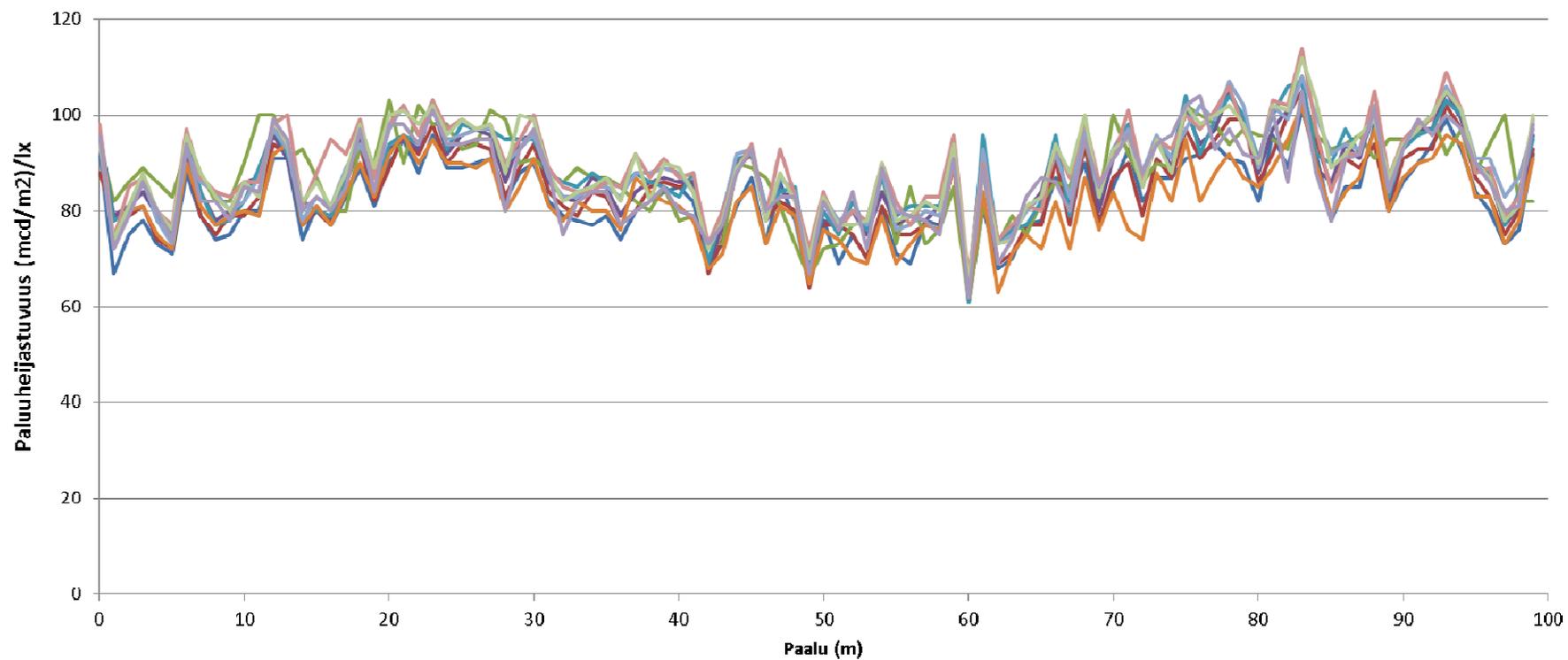
RESULTS – HAND-HELD DEVICES 2017



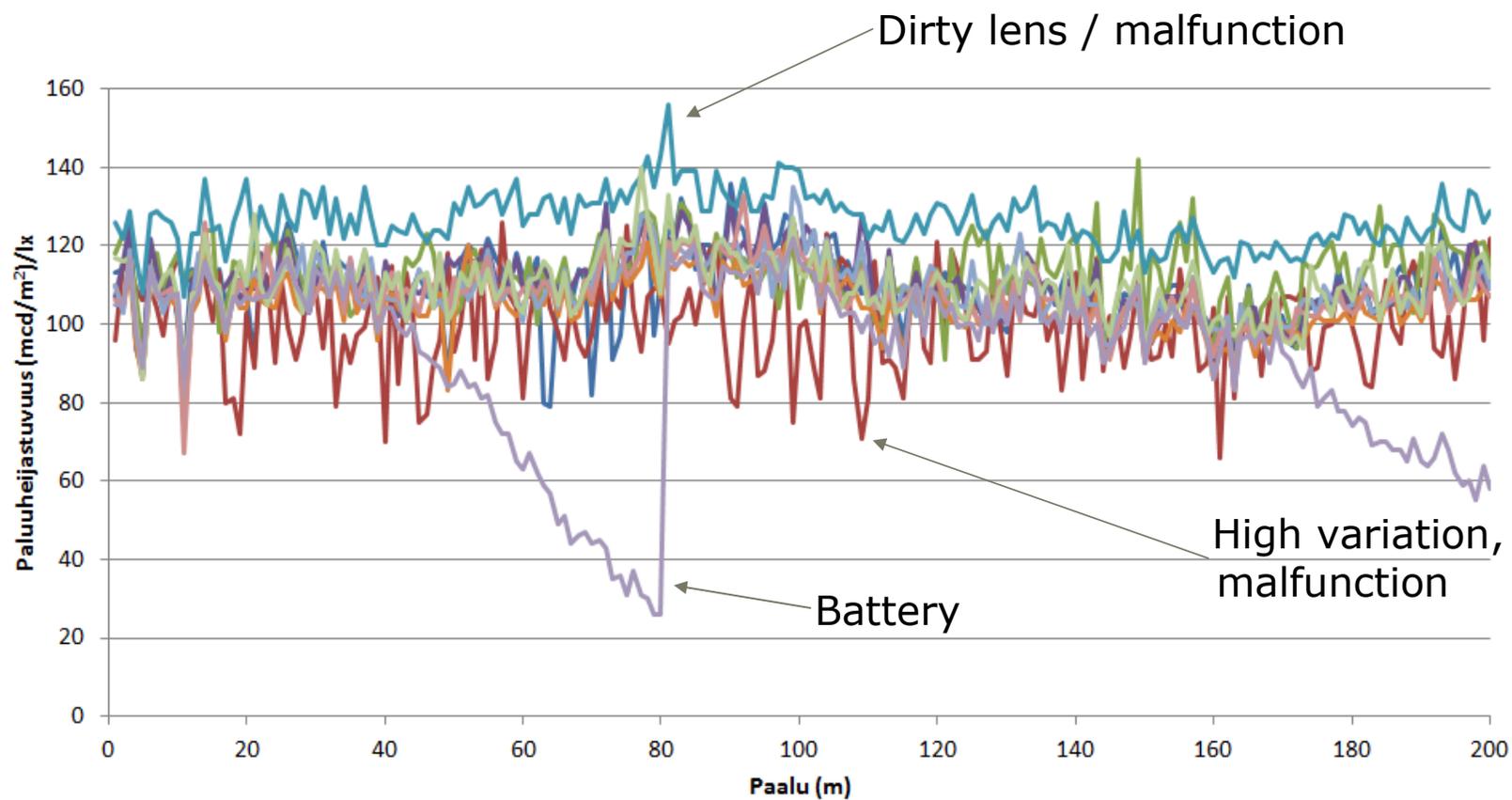
- Small differences between devices
- Small confidence intervals (+/- 1-3 units)

Device	Deviation from total average	Deviation %
1	-2,6	-3,3 %
2	-3,1	-4,1 %
3	2,2	2,9 %
4	0,4	0,6 %
5	1,7	2,3 %
6	-3,6	-4,8 %
7	0,9	1,2 %
8	2,8	3,7 %
9	1,5	2,0 %
10	-0,4	-0,5 %

RESULTS – HAND-HELD DEVICES 2017

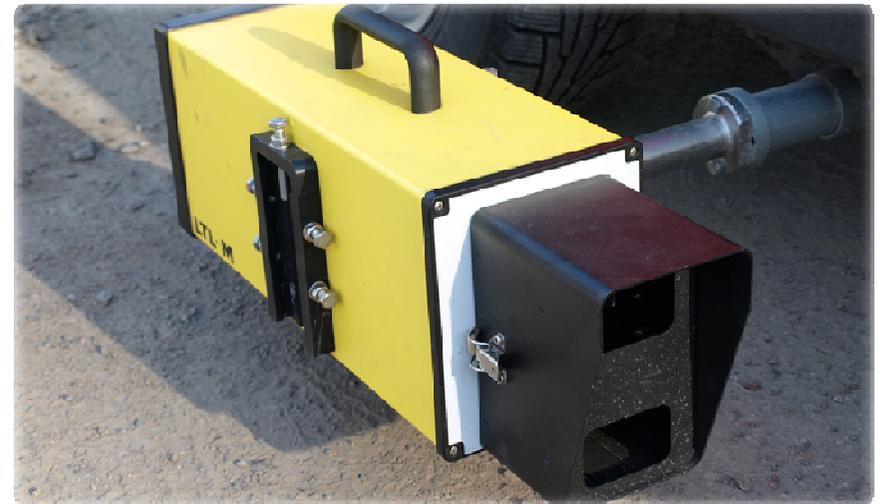


HAND-HELD DEVICES 2014



CRITICAL FOR QUALITY

- Regular and systematic calibration
- Clean lenses
- Driving style
- Careful reporting of deviations
- Active monitoring on results during the drive
- Sum up after the measurements
- Cleaning and maintenance of the device (batteries on hand-held devices)
- Conditions (moist, dust, dirt, rain etc.)



JAAKKO.DIETRICH@RAMBOLL.FI
040 5922 954

RAMBOLL