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The Dutch exposimeter study: Developing an Activity Exposure Matrix (EMF – AEM)

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Goal of EMF-AEM project

- In Dutch national EMF&Health Programme by ZonMw
- Characterise “true” exposure during everyday activities in 13 frequency bands
- Develop a tool to select highly vs. lowly exposed groups without actually measuring
- Preparation future epidemiological studies
- Collaboration:



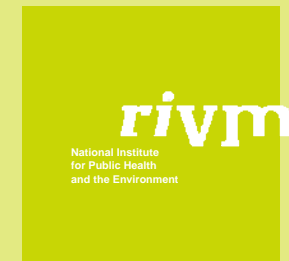
Stages of EMF-AEM project



1. Calibration and Uncertainties

2. Scenario driven measurements temporary workers

- carrying RF- and ELF-exposimeter, GPS and diary
- building Activity Exposure Matrix (AEM) for
30 common everyday activities
1 ELF magnetic and
12 RF-communication bands

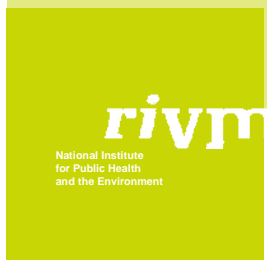


3. Population driven survey on volunteers (N=100)

- testing AEM and questionnaire on daily activity pattern for prediction qualities

A Cross-sectional study on aspecific effects

B Cohort study on hard end effects



ELF measurements in 1 band



- 8 EMDEX Lite

- Bandwidth 40 - 1000 Hz
- Sampling interval 4 s - 20 min
- Dimensions 1.0" x 2.4" x 4.7" (2.5 x 6.0 x 12.0 cm)
- Weight 6 ounces (170 grams)
- Data Memory 512Kb
- Meas. Accuracy ± 4 %

- Powerlines, powergrid, household appliances, tools

RF measurements

- 11 EME Spy (12 bands) Satimo (formerly known as Antennessa)



MECHANICAL CHARACTERISTICS		
Dimensions		195 x 95.4 x 75 mm (L x l x h)
Weight		450 g
Ingress protection		IP 43
MAIN CHARACTERISTICS		
Frequency band		FM, TV3, TETRA, TV4&5, GSM Tx, GSM Rx, DCS Tx, DCS Rx, DECT, UMTS Tx, UMTS Rx, WiFi
Axial isotropy	FM	$\pm 1,3$ dB
	TV3	$\pm 1,3$ dB
	TETRA	$\pm 1,2$ dB
	TV4&5	$\pm 0,9$ dB
	GSM Tx	$\pm 1,8$ dB
	GSM Rx	$\pm 0,8$ dB
	DCS Tx	$\pm 1,4$ dB
	DCS Rx	$\pm 1,0$ dB
	DECT	$\pm 1,3$ dB
	UMTS Tx	$\pm 0,8$ dB
	UMTS Rx	$\pm 1,8$ dB
	WiFi	$\pm 3,3$ dB
Lower detection limit		0,05 V/m
Upper detection limit		10 V/m

Not included:

GSM-r 876.1 MHz

Mariphone 156 MHz

Amateurradio 146 MHz

etc

Measurement uncertainties using the EME SPY 121

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Correction factors: what to do?

- Goal:
 - Equalise differences between EME Spy units
(**necessary** for contrast between activities)
 - Equalise differences between frequency bands
(less necessary, only for “true” exposure)
- Based on:
 - Out of band response
 - Precision within band
 - Response at middle of band
 - Multiple signals / sources
 - Isotropy / influence of body
 - Polarisation
- Do these features change over time???

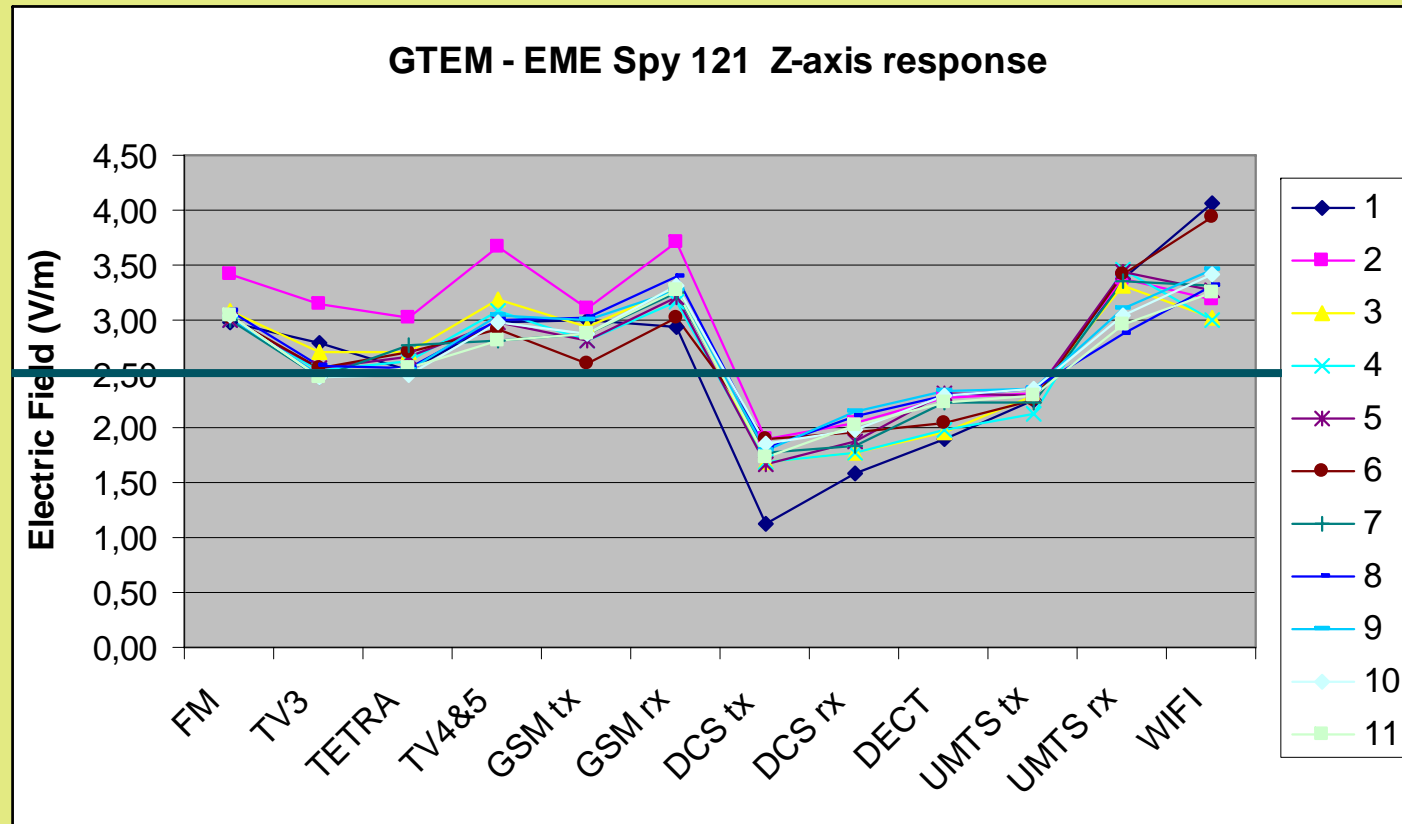
Calibration GHz Transverse ElectroMagnetic (GTEM) cell

Do all devices measure the same field?



Variability per unit ☺

Input = 2.5 V/m

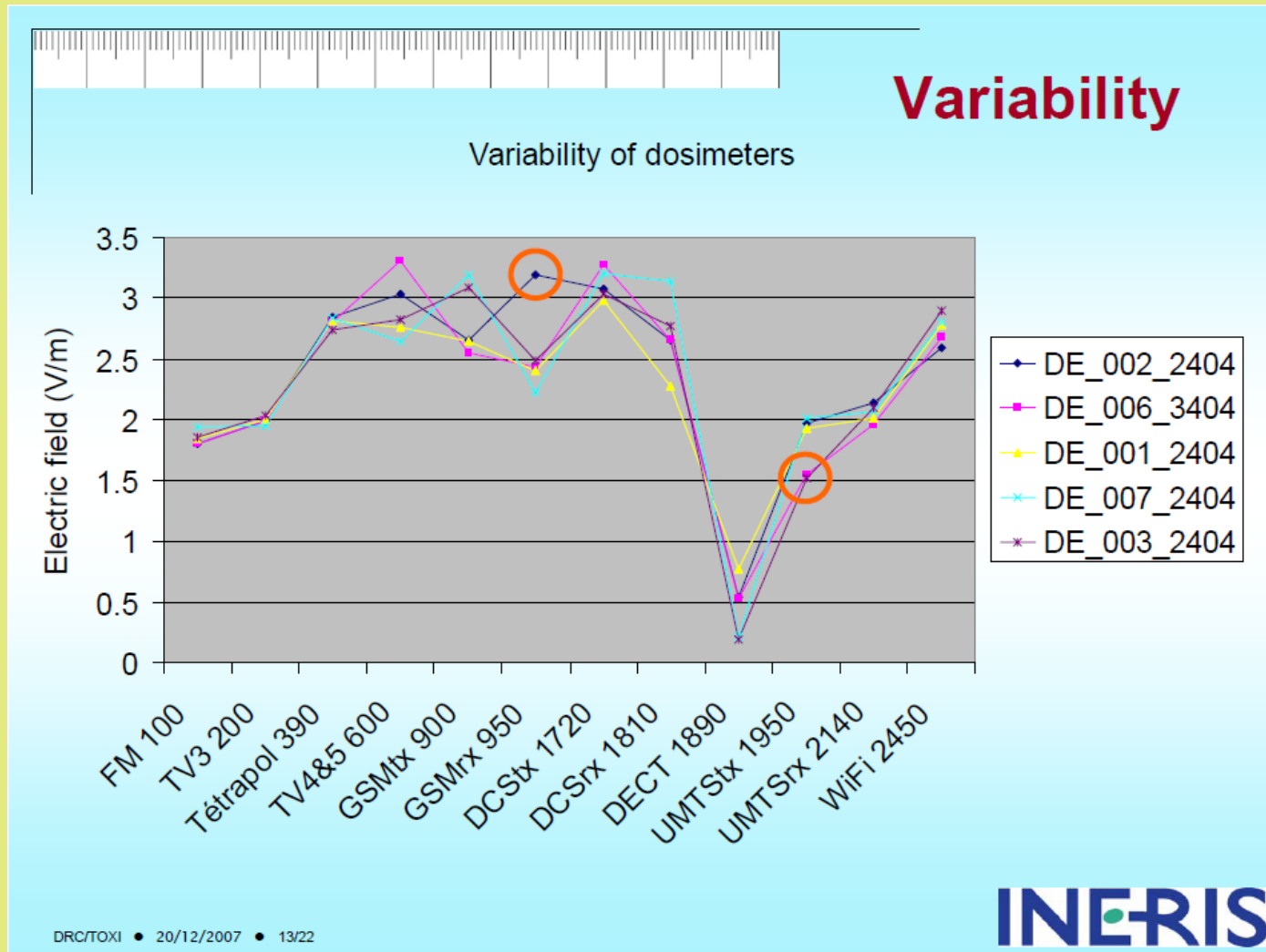


Too low: UMTStx, DECT, DCSrx, DCStx

Correction factors (input/response) typically 0.7 – 1.5

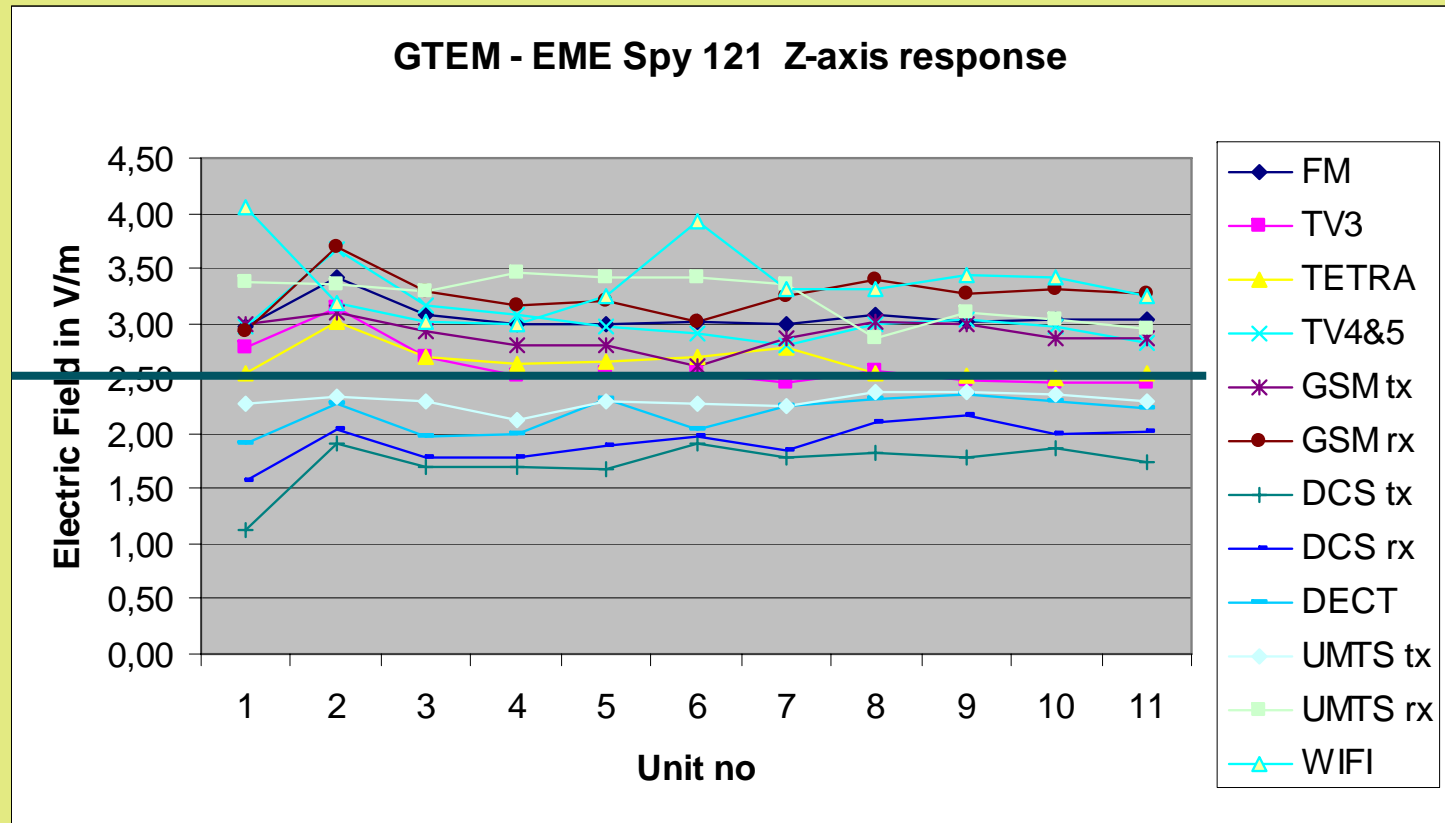
unit 1: broke, repaired unit 2: tends to give higher registrations than rest

Variability EME Spy 120 (France)



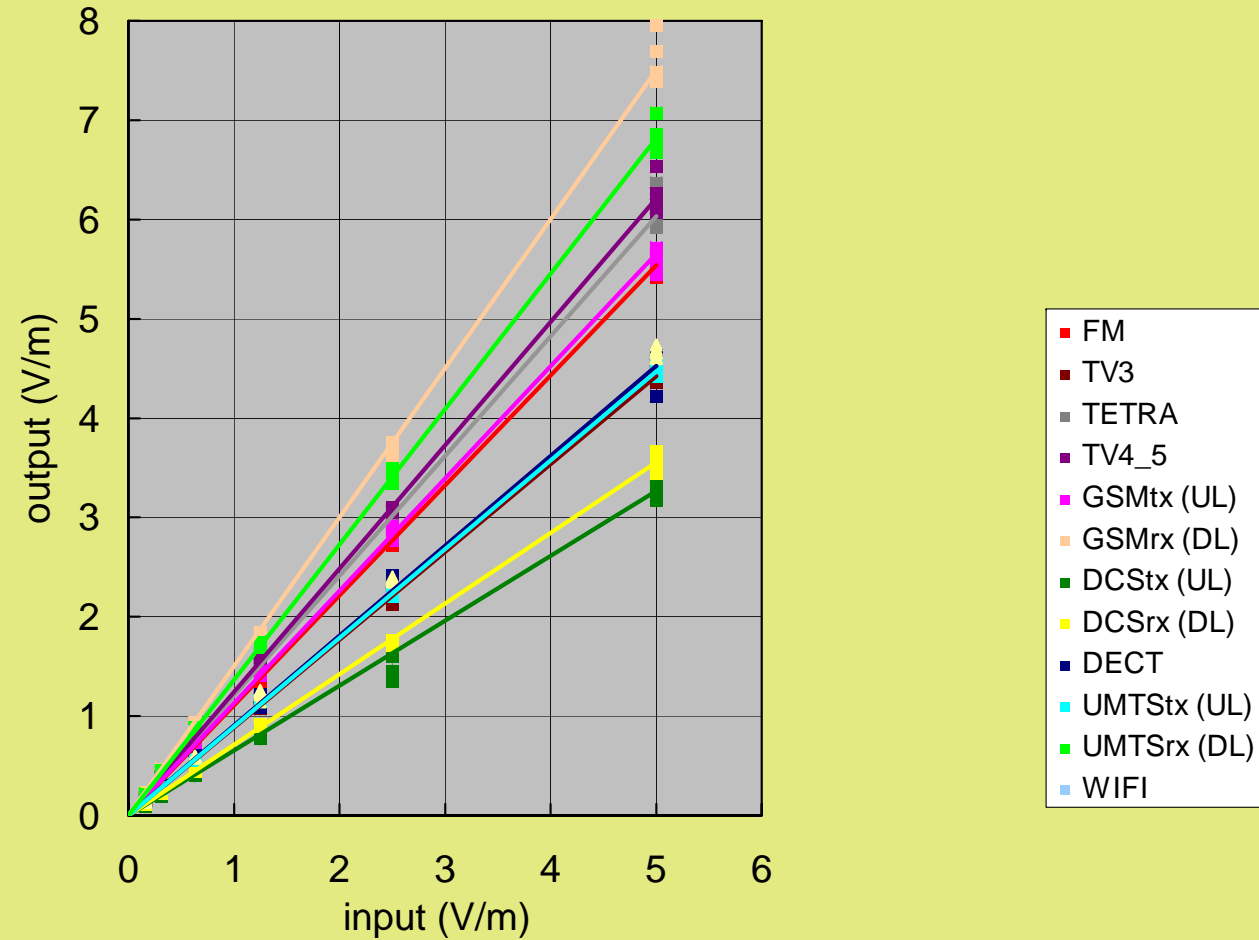
Variability within frequencyband ☺

Input = 2.5 V/m

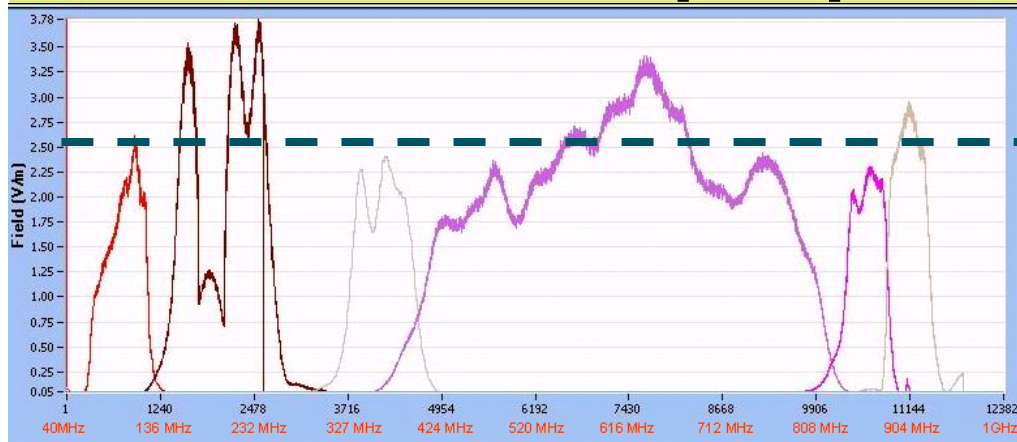


Too low: UMTStx, DECT, DCSrx, DCStx

Linearity (trendlines) 😊

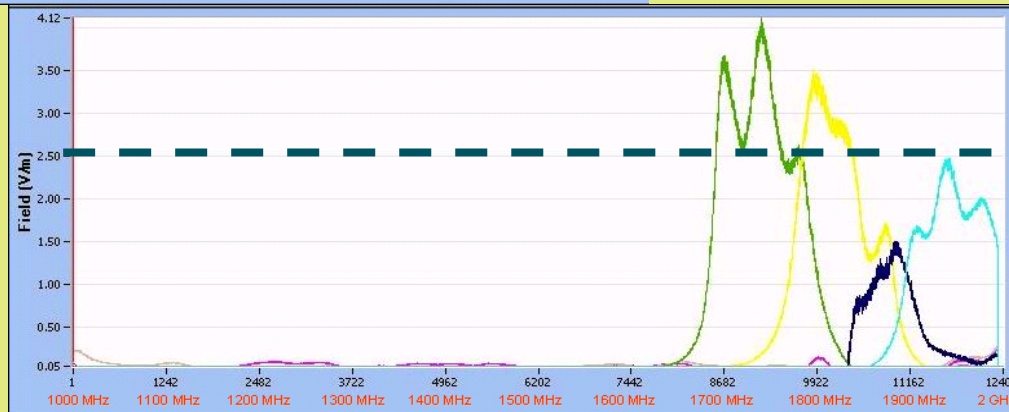


Out of band resp & precision within band ☹️



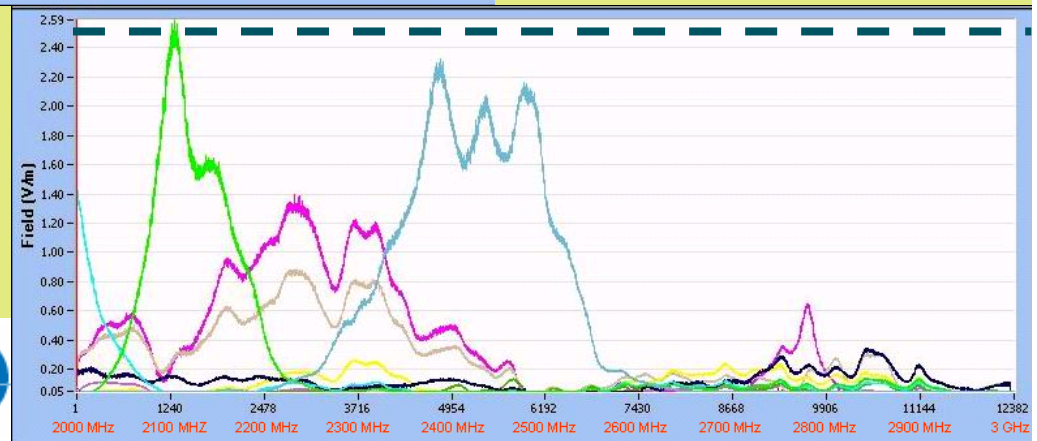
Band label	TDMA
88 - 108 MHz	
174 - 223 MHz	
380 - 400 MHz	TDMA
470 - 830 MHz	
880 - 915 MHz	TDMA
925 - 960 MHz	
1710 - 1785 MHz	TDMA
1805 - 1880 MHz	
1880 - 1900 MHz	
1920 - 1980 MHz	
2110 - 2170 MHz	TDMA
2400 - 2500 MHz	TDMA
TOTAL	

UL = Up Link
DL = Down Link



Unit 7

• Input 2.5 V/m



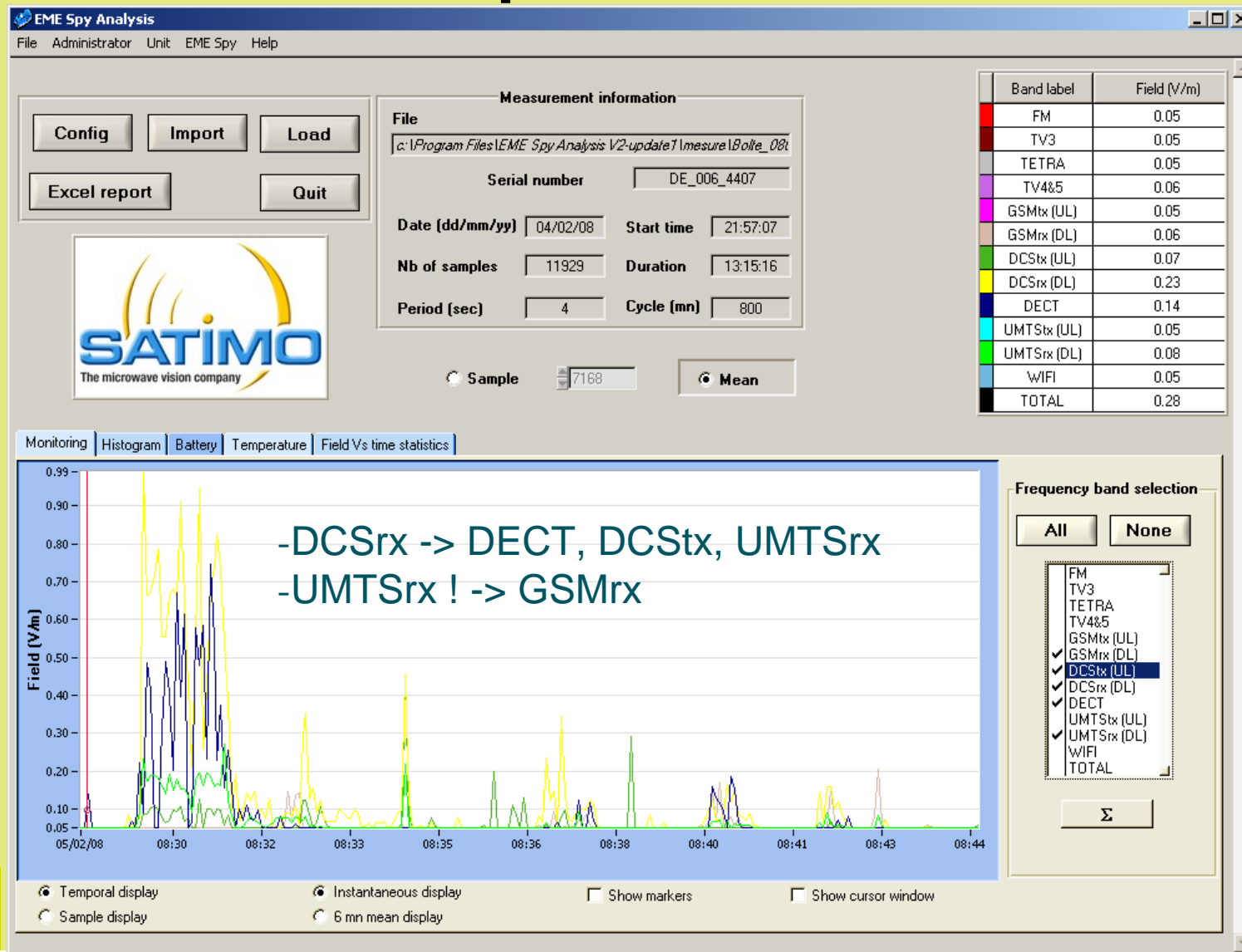
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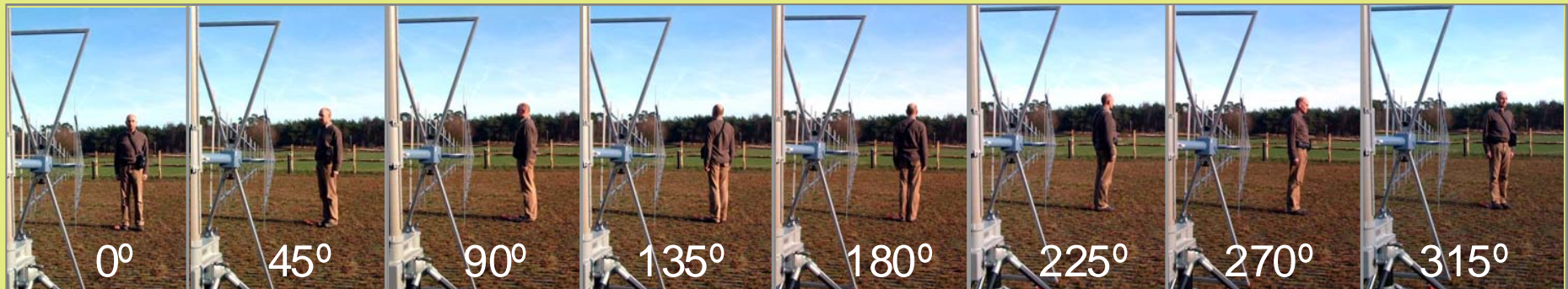
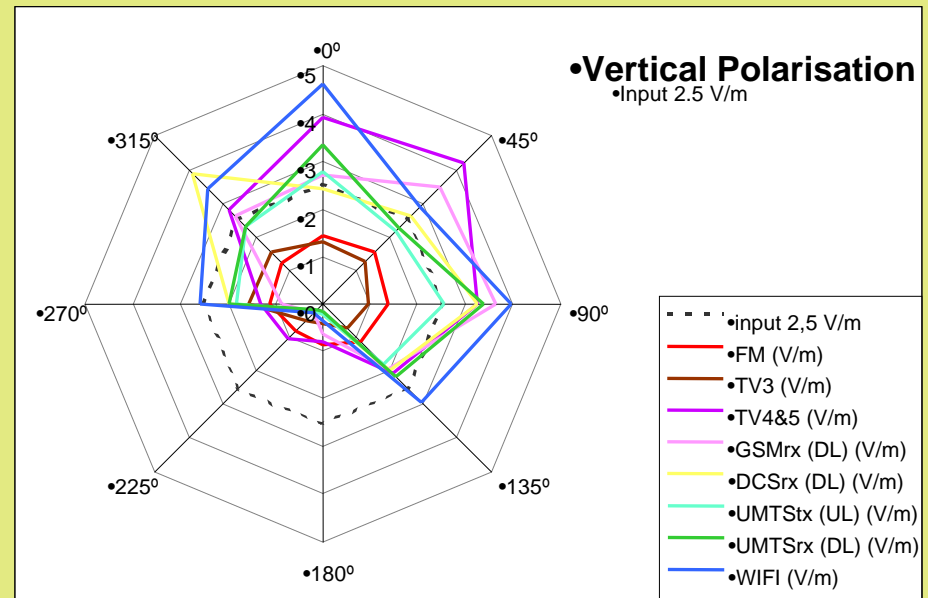
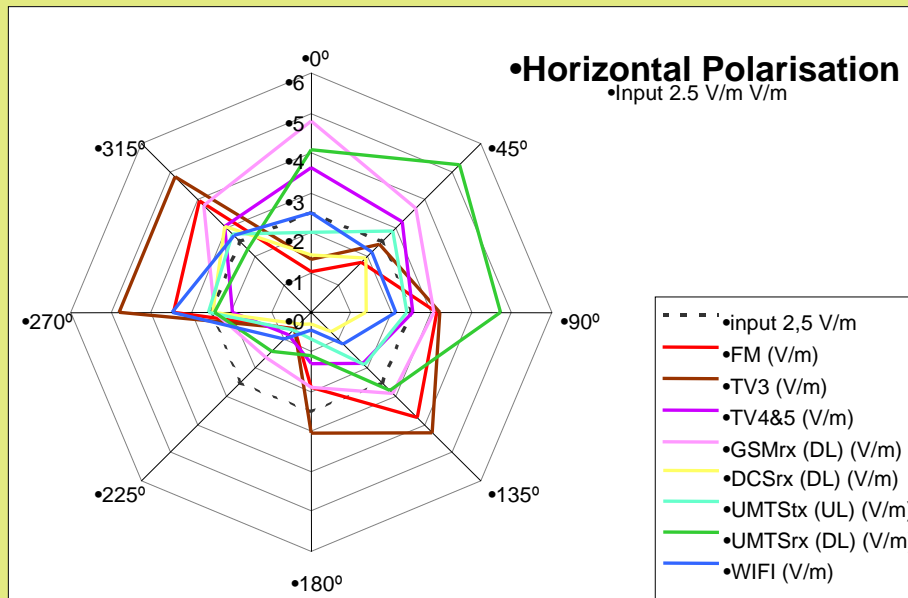
Out-of-band response in field ☺/☹



Open Area Test Site (OATS)



Influence of the body (linear V/m scale)



unit 7

Concluding remarks

- Correction factors for different response of 11 RF exposimeters necessary, based on:

- Out of band response	test	software filter	😊/😞
- Precision within band	f_{in} =unknown	error margin	😞
- Influence of body	motion	average?	😊/😞
- Polarisation	reflections	average?	😊/😞
- Multiple signals / sources	no detect	unknown error	😞 😞
- Response & linearity	constant factor	input/response	😊

- Do these features change over time???

Measurements & observations

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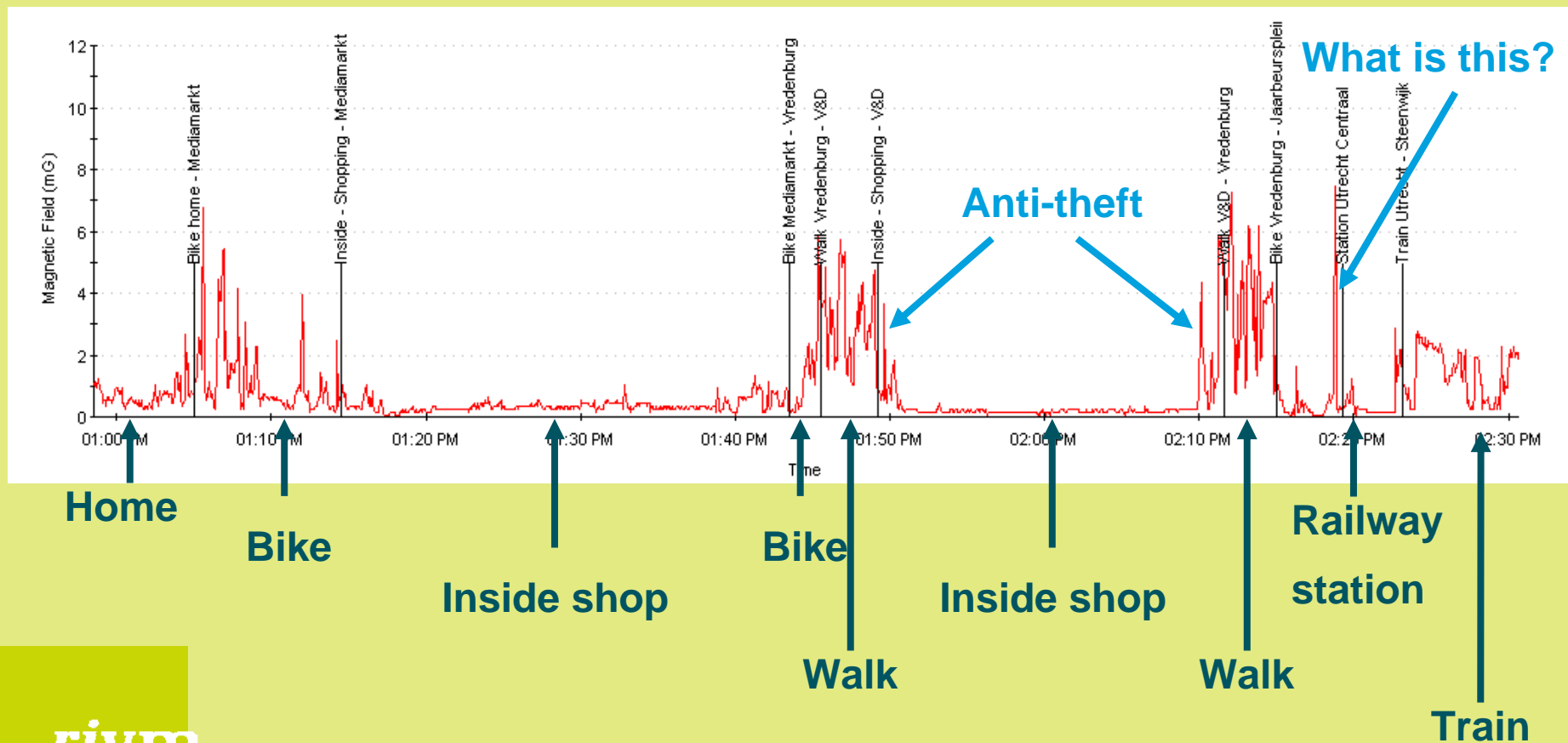


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19

Magnetic B-field for activities in city centre



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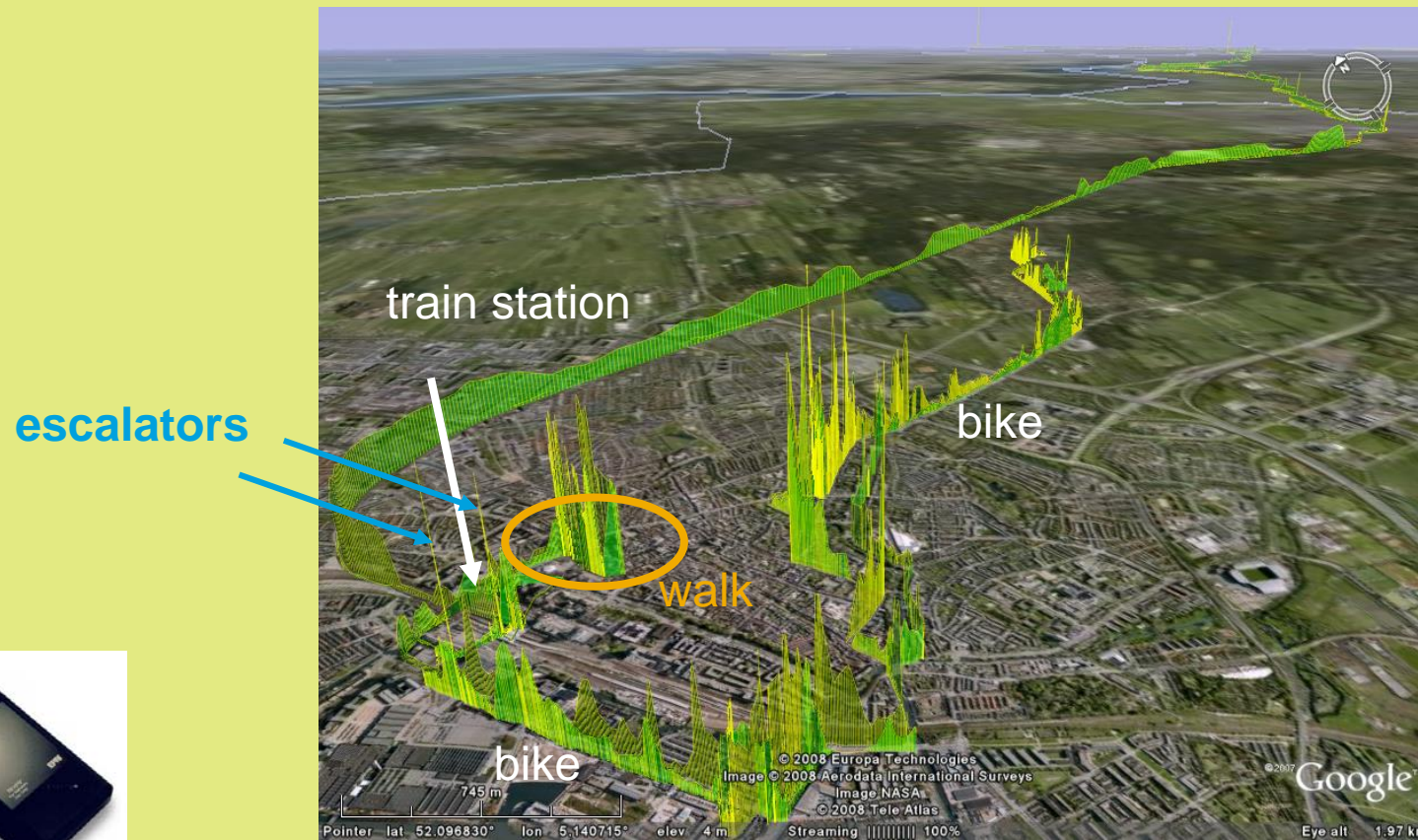
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20

Magnetic B-field in and around Utrecht city



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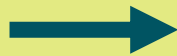
21

Temporal differences B-field: same location, different time

bike 21:15

bike 16:45

0,4
micro-
tesla



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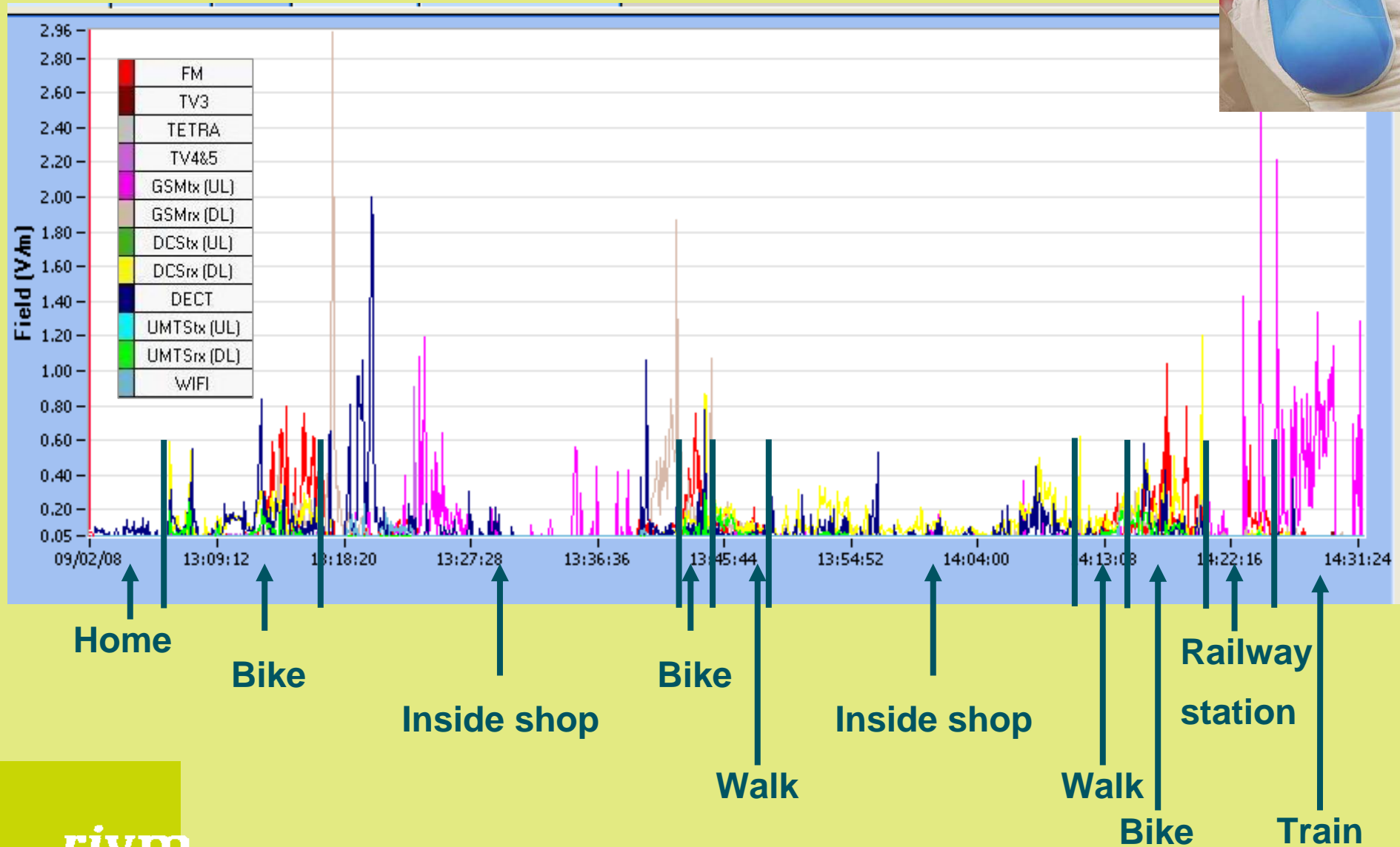
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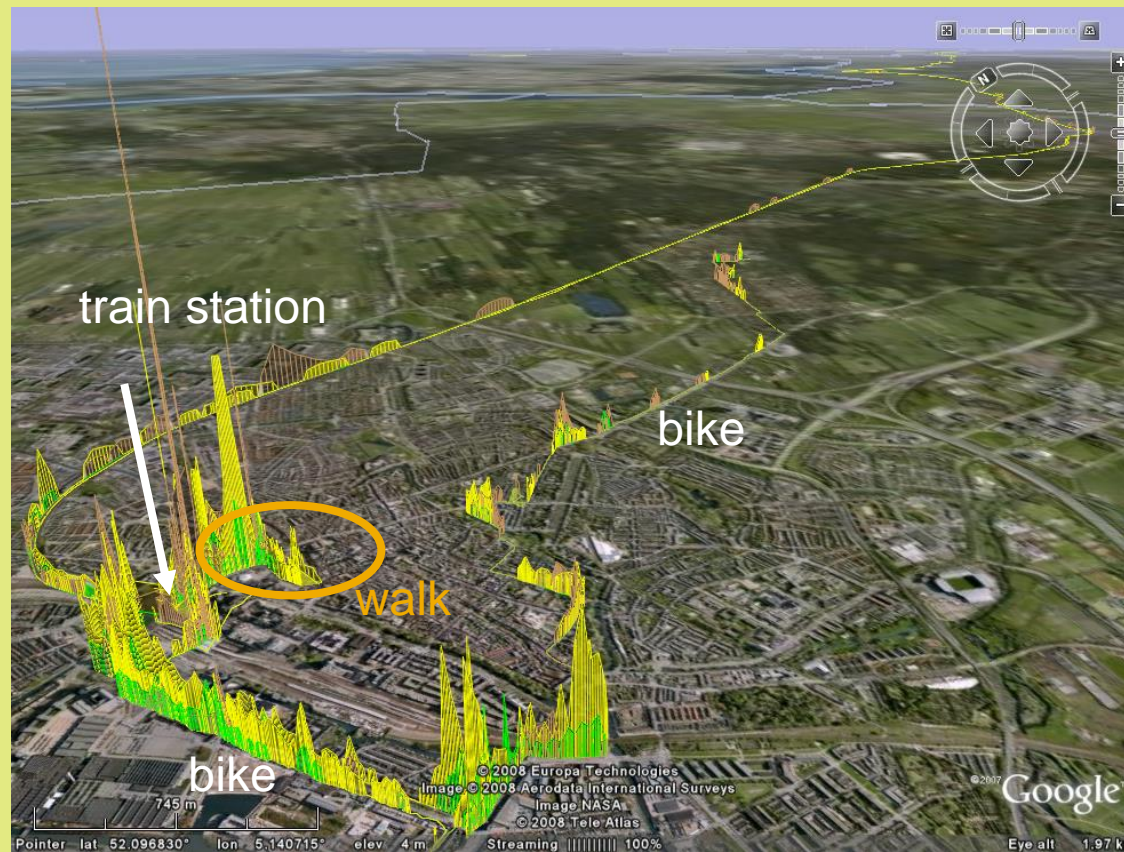
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Electric E-field activities in city centre



GSM, DCS and UMTS basestations



FM
TV3
TETRA
TV4&5
GSMtx (UL)
GSMrx (DL)
DCS tx (UL)
DCSrx (DL)
DECT
UMTS tx (UL)
UMTS rx (DL)
WIFI



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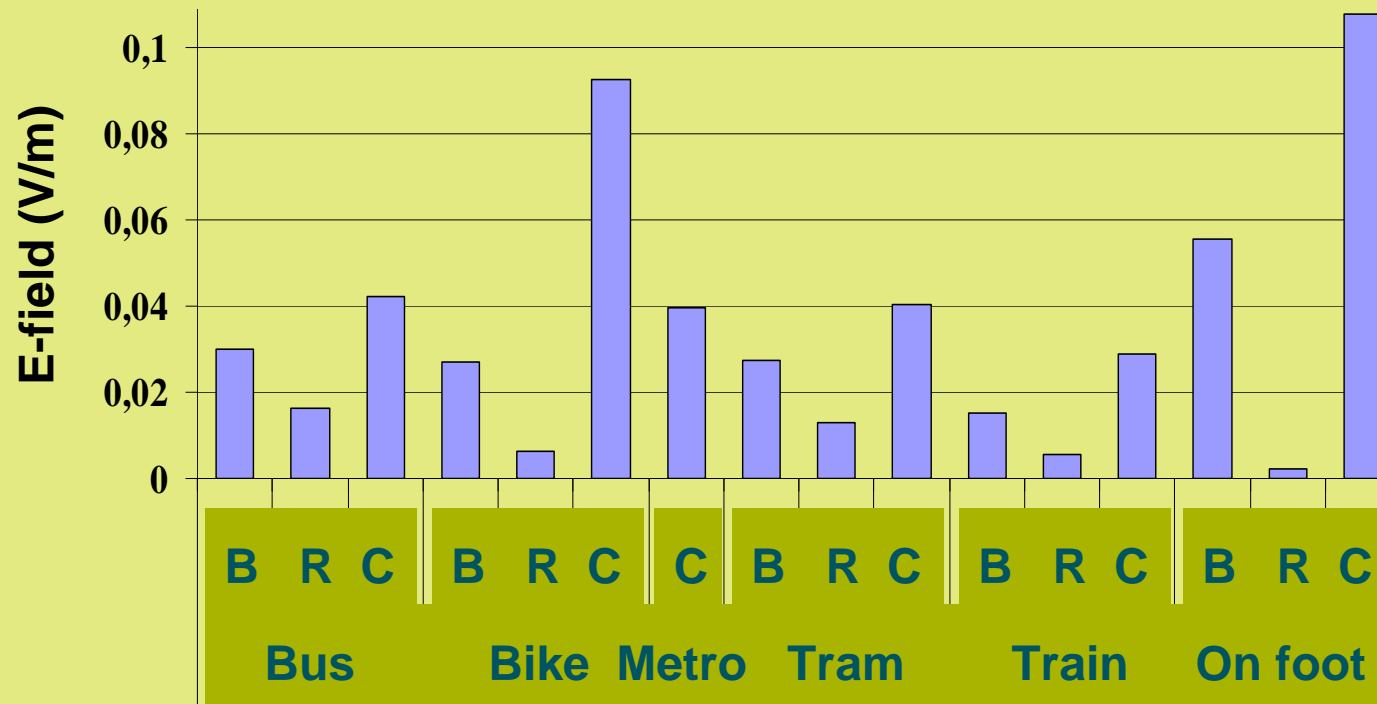
24

FM and TV broadcasting



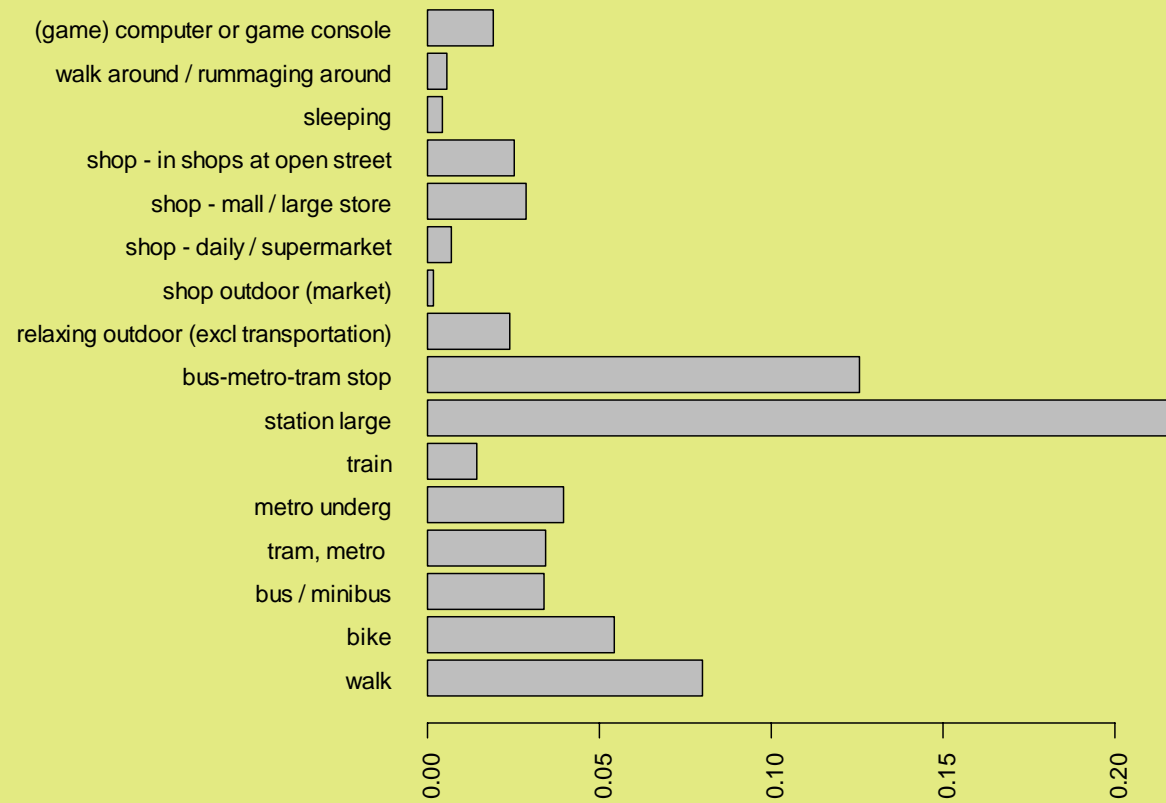
Some preliminary outcomes on the scenario driven survey ...

Spatial differences: GSMrx transportation



Built up area - Rural - Centre

Stagellb: Mean GSMrx



Stage II: Fieldwork

- September 2009 – January 2010
- N=100 selected in Amsterdam and surroundings
- screened for **diversity**:
 - sex
 - Living environment and housing
 - city centre, city, city outskirts, village centre, village outskirts
 - single, chained, apartment building
 - employed / unemployed
 - main mode of transportation
 - Age: 18-24, 25-35, 35-45, 45-55, 55-65, 65-

Concluding Remarks

- Correction factors due to calibration of the EME Spy are necessary, range for E-field: 0.7 – 1.5
- Body shielding should be taken into account and can lead to 2 dB measurement error
- Contrasting everyday activities can be found,
 - main differences RF indoor – outdoor, highest at station
- Temporal differences day – night
- Spatial differences Centre – Built-up area – Rural
 - Centre / Rural GSMrx: factor 5

Acknowledgements

- The EMF-AEM team at RIVM, Radio Communications Agency and Utrecht University
- The Netherlands organisation for health research and development (ZonMw) for funding this study under the Dutch national Electromagnetic Fields & Health Programme

Stage IIb: dayscenarios & routes

DayScenario 2: Rotterdam - Den Haag - late

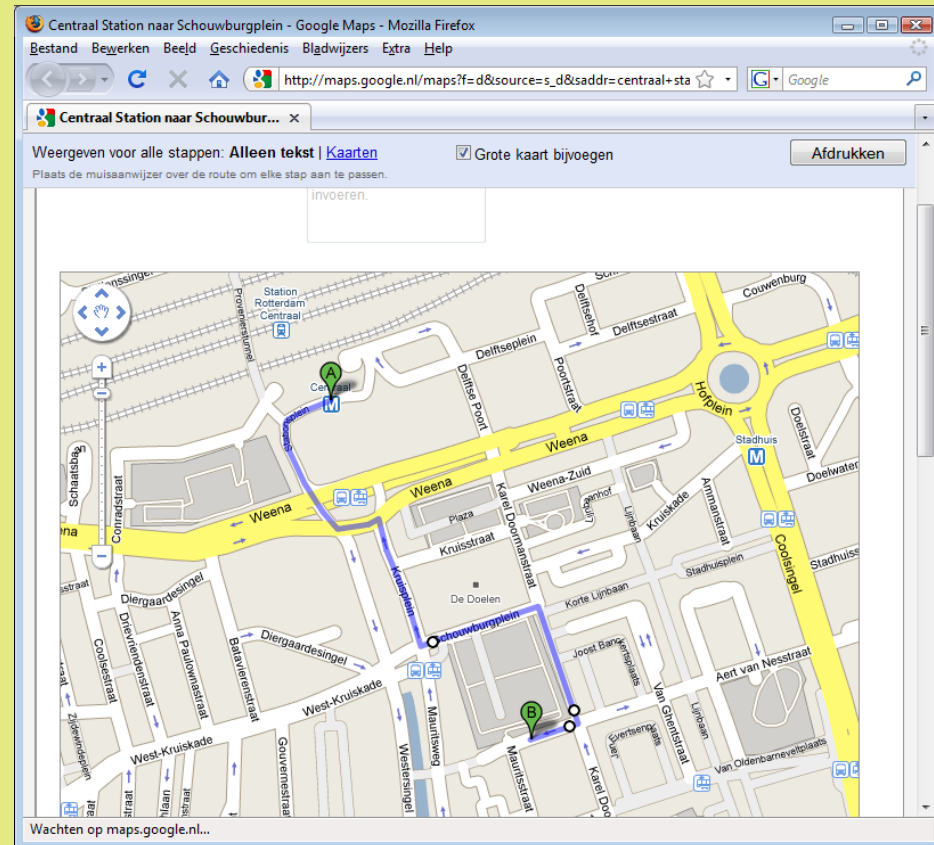
Start time: 12.00u

End time: 21.00u

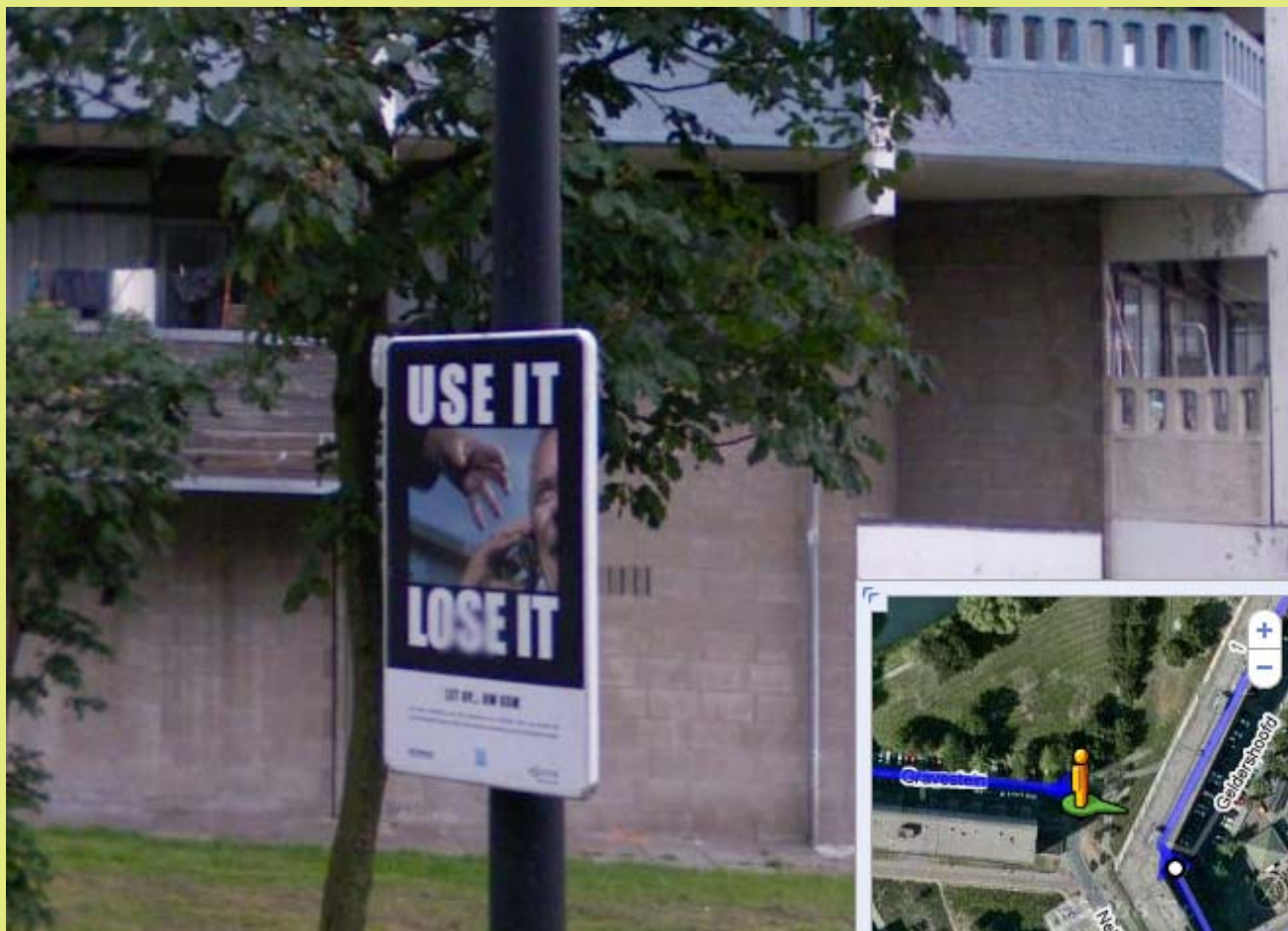
The scenario starts at 12.00u at Utrecht Central station.

Preferred is to come to the station by bike, because you have to cycle around in the evening. If it is not possible to bring your bike, then rent a bike at the station.

- 12.03 – 12.33u Take the train at Utrecht Central Station to Rotterdam Alexander (platform (railway) 9a)
- 12.33 – 12.50u Walk around at the station and walk to the subway (Do not forget to buy an OV-chipkaart in this time also!)
- 12.51 – 13.20u Take the subway at 12.51u in the direction of Rotterdam Central There is a transfer/switch-over at metrostation(subwaystation) Beurs (see [routedescription 1](#)).
- 13.20 - 13.35u Walk out of Rotterdam Central Station in the direction of Schouwburgplein and enter café Floor (Schouwburgplein 28, see [routedescription 2](#)).



Stage IIb: dayscenarios & routes



Future plans

- Indoor measurements at home of volunteers
- Calculate exposure model Buergi similar to uergi et al. 2009 and Frei et al. 2009
- Prediction model of exposure
- Application of Activity Exposure Matrix in:
 - Cross-sectional study on aspecific effects (RIVM)
 - Cohort study on hard endpoints (Utrecht University)