

Third DTIF Workshop at the JRC in Ispra

UWB GPR activities for mine detection at FGAN-FHR

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Introduction

Measurements at WTD52

Radar system parameter

Measurements at Ispra

Signal analysis

Conclusions



Introduction Radar system parameters Signalanalysis Measurements at WTD 52 Measurements at JRC Conclusions

Introduction (1)

Military constraints	Humanitarian constraints
demining time critical	time less demanding
crisis situation	off-crisis
demining to get movement freedom	demining rate 99.6% needed
relative high risk acceptable	no life risk acceptable
environmental destruction acceptable	minimize environmental destruction
expensive sensors operated by specialists	cheap systems usable by low education operators



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Introduction (2)

Aim of Investigations

- Potential contribution of radar for mine detection and classification.
- Background knowledge at FGAN on detection and classification of radar illuminated targets.
- Focus on close-in detection, hand held and vehicular mounted.
- Small activity of FGAN.

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Radar system parameters (1)

GPR system components

```

graph LR
    subgraph PC
        SP[Signal-processing]
        C[controller]
    end
    subgraph HU[head unit & antenna]
        PG[puls generation]
        TA[transmit antenna]
        RA[receive antenna]
        ADC[A/D converter]
    end
    PC <--> HU
    HU --> VUT[volume under test]
    VUT --> HU
    VUT --- T[target]
  
```

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Radar system parameters (2)

Typical ERA SPRscan GPR system parameters

Antenna bandwidth	2 GHz
puls length	1.25ns (rise 0.4 ns)
PRF	1 MHz
samples/scan	512 (256)
samples averaging	20 (10)
max. record rate	100 scans/s
TVG slope	Fixed (*)
spatial sampling	1cm
synthetic time sampling	25 ps (n*25ps)
Polarization	parallel Rx only

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Radar system parameters (3)

Typical Geozondas GZ6 GPR system parameters

Antenna bandwidth	4 GHz (2.8-6.5GHz)
puls length	1ns, rise:0.1 ns
PRF	250 kHz
samples/scan	256 (variable)
samples averaging	1..256 (variable)
max. record rate	>60 scans/s
TVG slope	variable
spatial sampling	1cm
synthetic time sampling	Variable, >1.25ps
Polarisation	parallel&cross Rx

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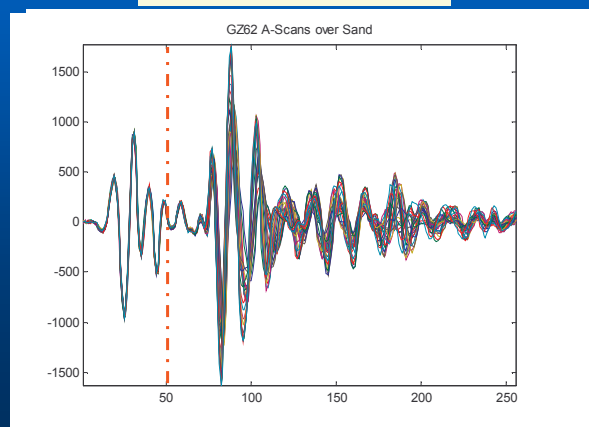
Radar system parameters (4)

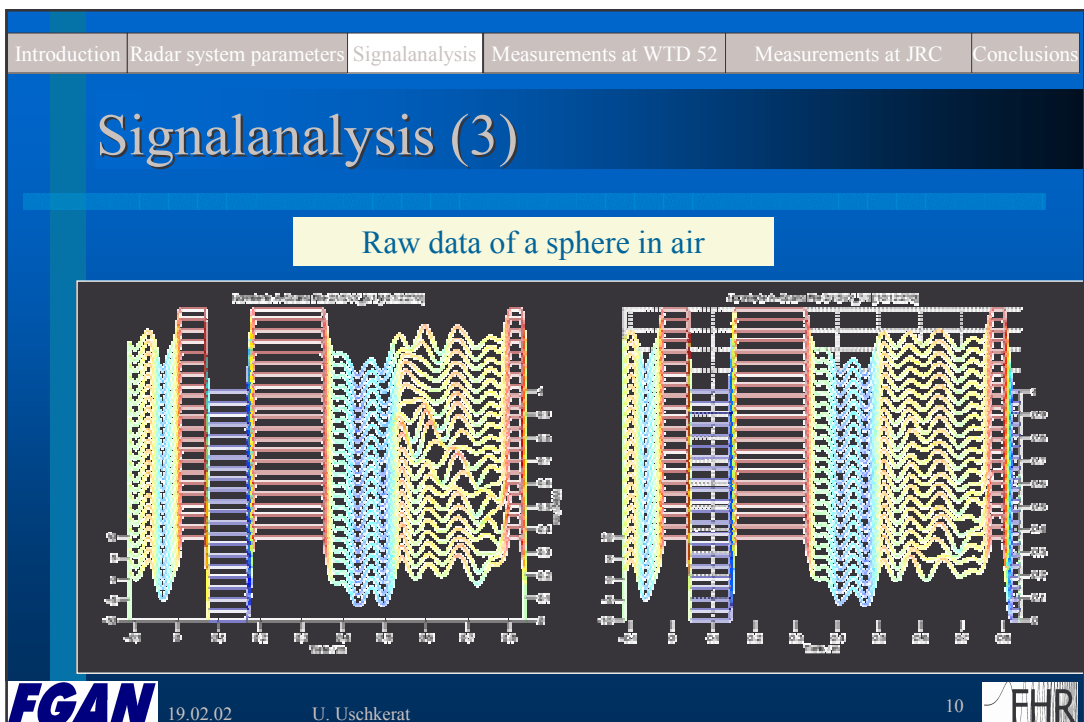
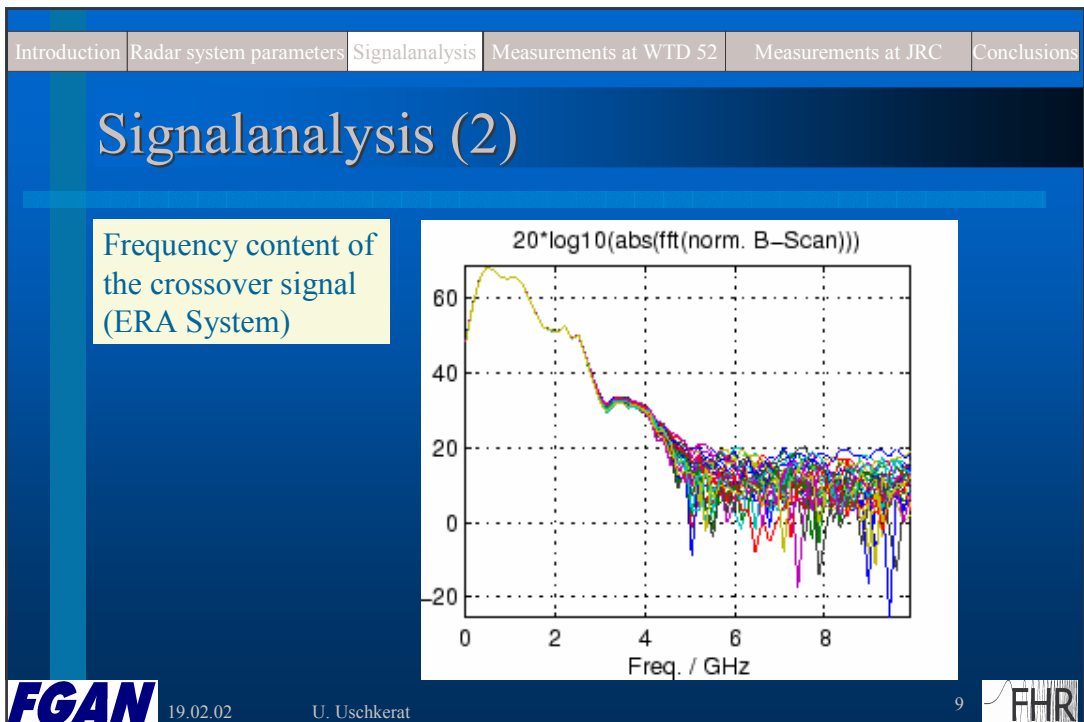
ERA System and GeoZondas System

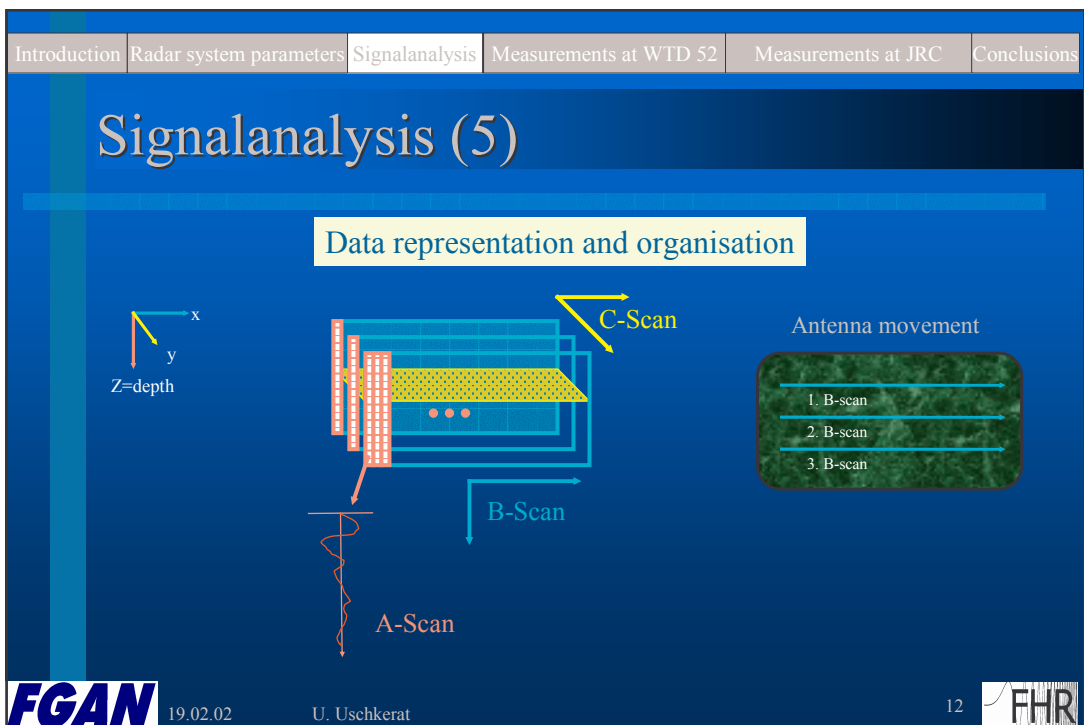
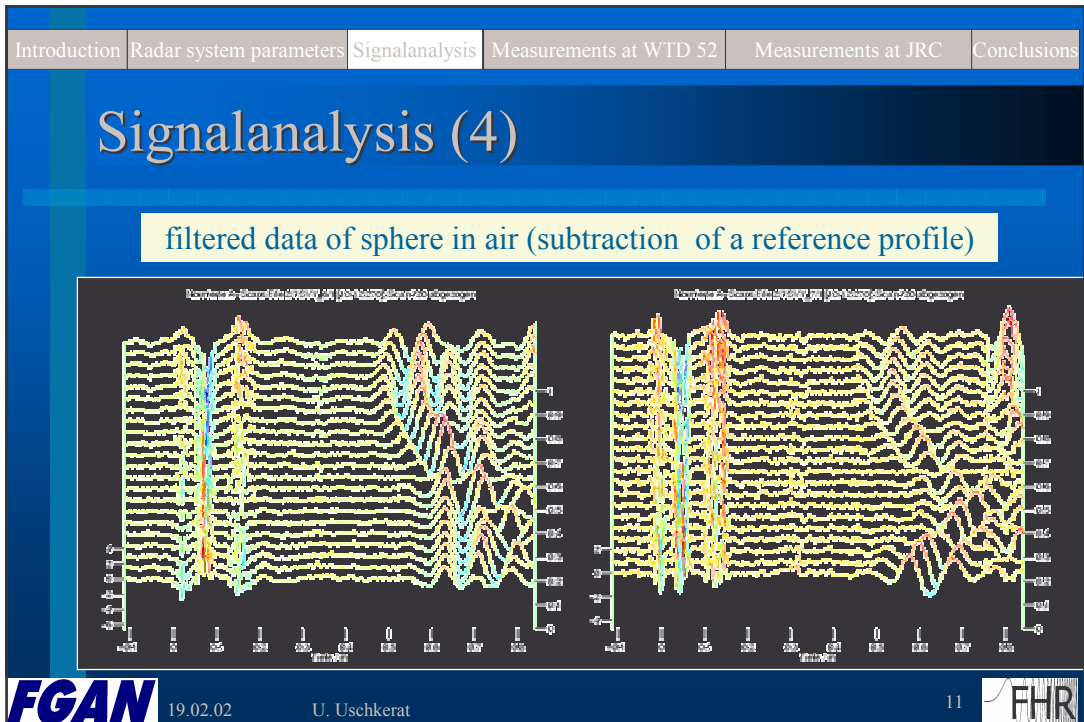


Signalanalysis (1)

A-Scan signals, GZ62







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Signalanalysis (6)

CFAR detector

Microsoft PowerPoint

want more?

```

graph LR
    subgraph Radar_data [Radar data]
        RD[Reference data  
(clutter & noise)]
        TD[Test data  
(clutter + noise + signal)]
    end
    P[Number of pixels to integrate]
    MLR[Maximum Likelihood Ratio]
    AO[„analog output“  
(decision variable)]
    BE[Binary detection  
(>ε)]
    SE[Statistical evaluation]
    A[Alarms]
    Pfa[Pfa]
    Pd[Pd]

    RD --> MLR
    TD --> MLR
    P --> MLR
    MLR --> AO
    AO --> BE
    Pfa --> BE
    Pd --> BE
    BE --> SE
    SE --> BE
    BE --> A
  
```

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Measurements at WTD 52 (1)

Environments with inert mines

- Environment 1 wet lawn
- Environment 2 freeze protection gravel
- Environment 3 basalt crushed stone
- Environment 4 loamy soil
- Environment 5 sand/gravel mixture

Wooden measurement frame

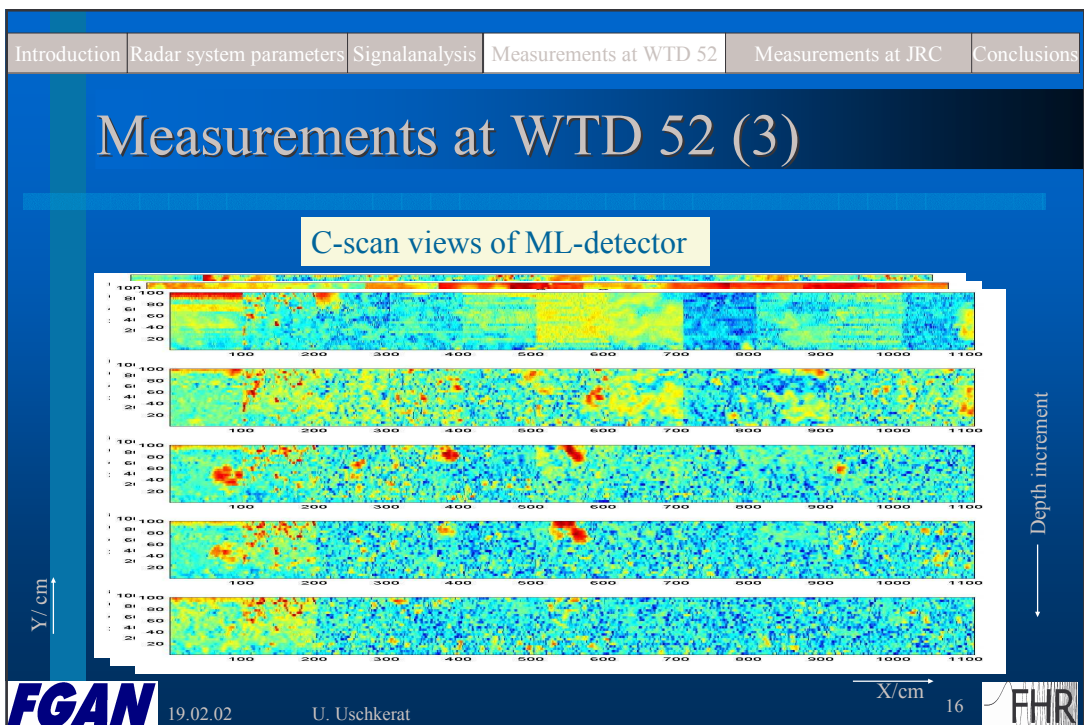
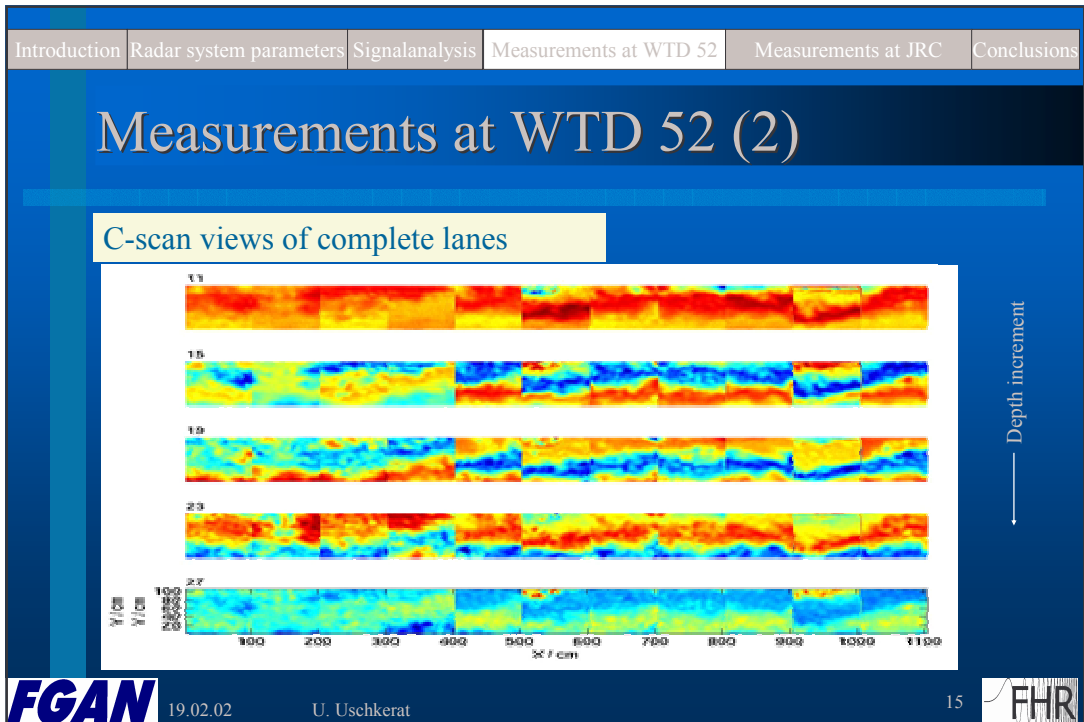
save area

Area under Test

mine suspected area

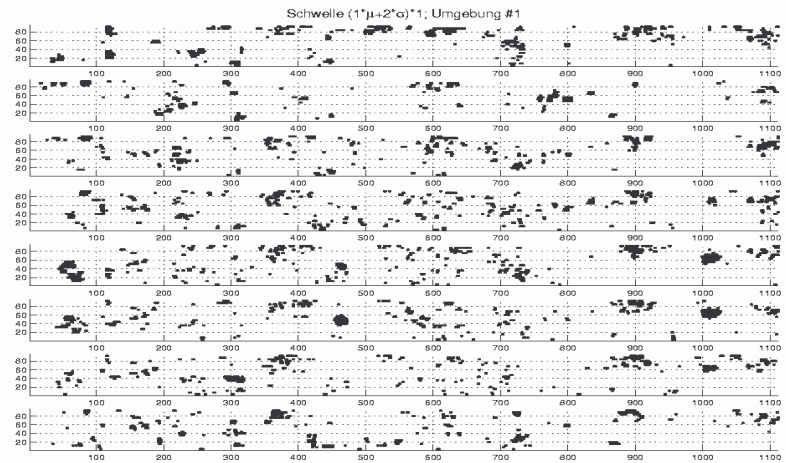
Antenna

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Measurements at WTD 52 (4)

Binary
detection
plot,
 $P_{fa}=2.27E-2$



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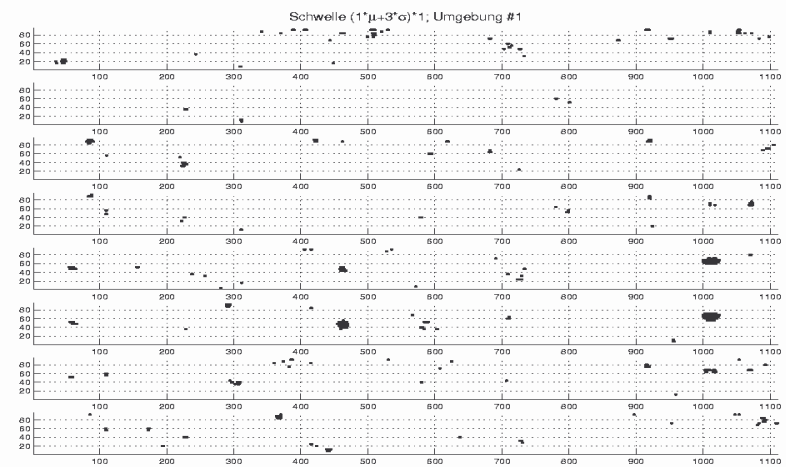
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Measurements at WTD 52 (5)

Binary
detection
plot,
 $P_{fa}=2.2E-3$



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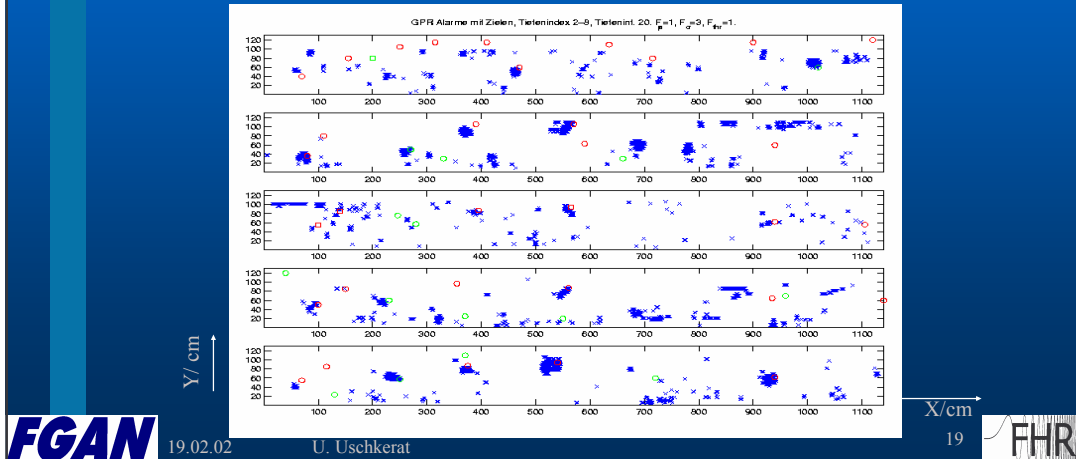
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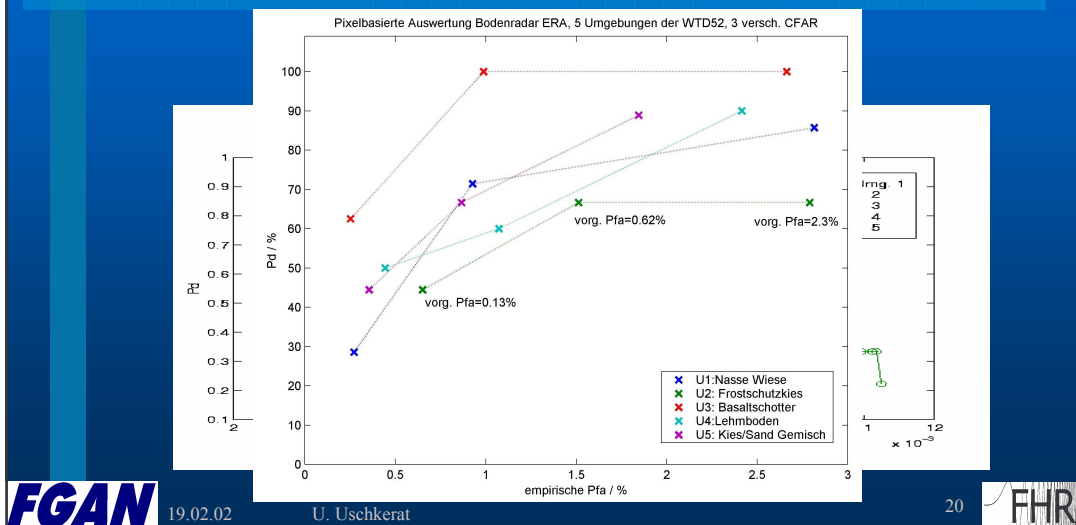
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Measurements at WTD 52 (6)

Evaluation towards a ROC



Measurements at WTD 52 (7)



Measurements at Ispra (1)

- MsMs Group collect data for sensor fusion research in the area of demining.
- FGAN-FOM already member in that group
- FGAN-FHR contributes measurements done with both radar systems.
- For the first time of MsMs Group GPR data for the whole test area was delivered as raw data.
- Of course, this data is not ideal and there are outliers..

Measurements at Ispra (2)



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Measurements at Ispra (3)

GPR system	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot7
ERA 2GHz	A-C at h=16cm; A-C at h=30cm; A at v=0.8m/s	A-C at h=16cm; A-C at h=30cm; C at v=0.8m/s	A-C at h=16cm; A-C at h=30cm	A-C at h=16cm; B at v=0.8m/s	A-C at h=16cm	A-C at h=16cm	A-C at h=16cm
Geozondas	B-C at h=15cm	B-C at h=15cm	B-C at h=15cm; B at h=15cm (Nbscan=78); A at h=15cm, (Nbscan=66, Vx=0.05m/s, dx=1cm!)	B-C at h=15cm; A,B at 40ps, h=15cm;	C at h=15cm A at 40ps, h=24cm (Nbscan=89)).	B-C at h=15cm A at h=15cm (Nbscan=116)	A-C at h=15cm

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Measurements at Ispra, raw data plot 2b

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Conclusions (1)

Achievements

- Influence of different environments on mine detection investigated.
- Application of ML detector to measured data. Performance varies depending on soil/environment type.
- GPR data collection on the MsMs test site can be used for multisensor fusion research.

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Conclusions (2)

Near future tasks

- Continue experimental evaluation of ROC of radar sensor and detection algorithm.
- Implement and test clutter reduction algorithms.
- Implement and test classification algorithms.

Missing technology

- New antenna has two polarimetric channels for SCR and (hopefully) classification enhancement.
- time-stable hardware within some picoseconds over several minutes still needed.

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Conclusions (3)

Possible tasks for a co-operation

- test other detection and/or classification algorithms
→ *need for a common agreed software environment*
- share real data for a common database, common trials.
→ *need of comprehensive measurment description, ground truth data.*
- find standard parameters for comparison of different radar systems used in demining.
→ *due to near-field conditions and broadband waveform "old" radar standards are not applicable*

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Conclusions (4)

How to co-operate?

- EU humanitarian efforts: ESPRIT programs, efforts at JRC.
- EU military efforts: WEAG, CEPA-1 started January 2000 with a workshop in Rome. Since then an Outline Description is written, but there's still the problem of participation of non-profit and/or profit organizations (EUCLID *or* THALES rules).
- NATO military efforts: RTO research groups. Concerning mine detection and clearance efforts mostly MOD members are represented within those groups. Groups with only scientific researchers are missing!

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