

Beyond Ad-Clicks

Dirk Gorissen | @DirkGor

Nantes ML Meetup

17 October 2016

Nantes ML Meetup | @DirkGor

Me?

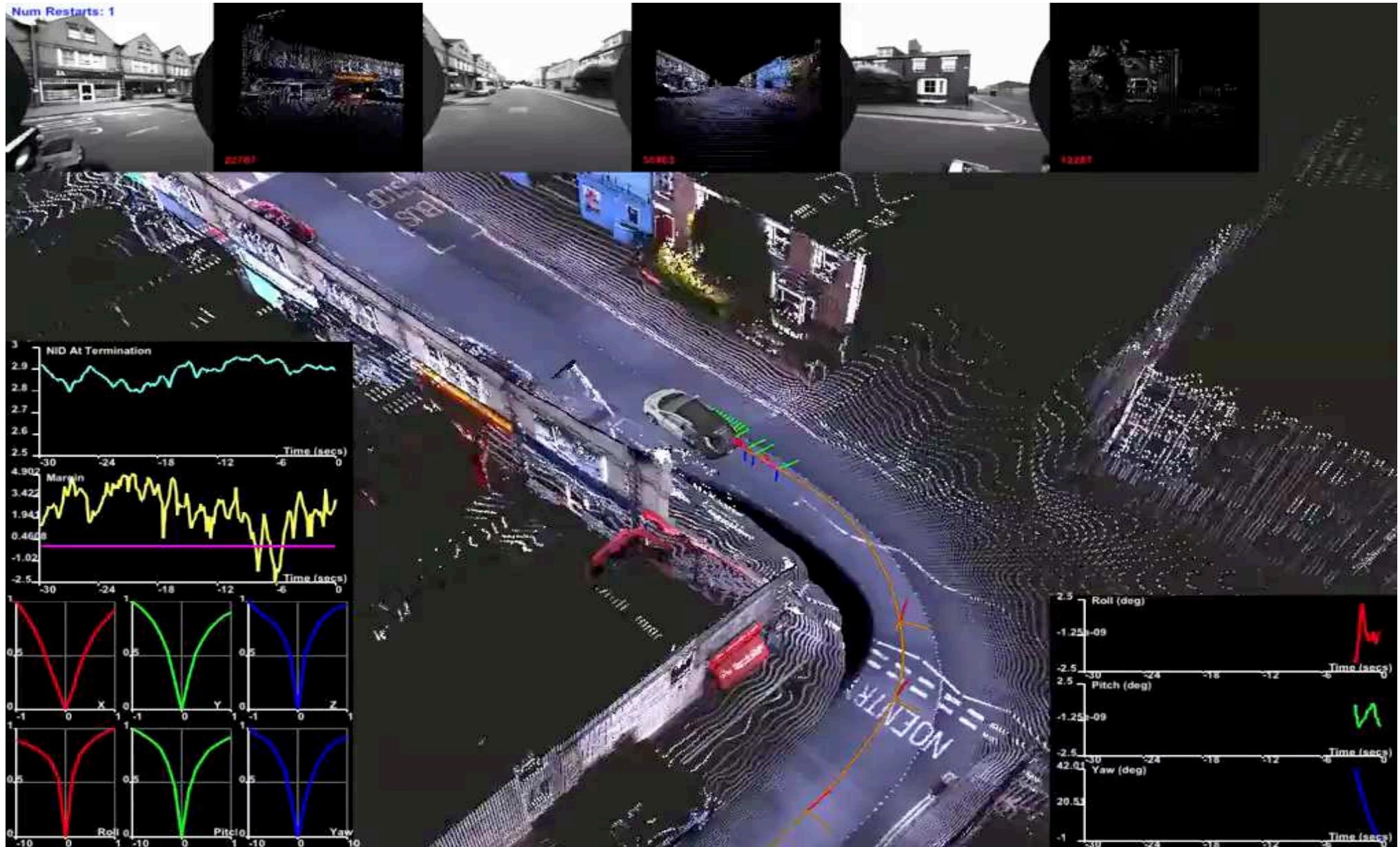


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  if (descriptions.length > (page * 5) + (currentImage - 1)) {
    document.getElementById(bigImageDesc).innerHTML = descriptions[page * 5 + currentImage - 1];
  }
}

function updateAllImages() {
  var i = 1;
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    var elementIdBig = 'bigImage' + i;
    ...
  }
}
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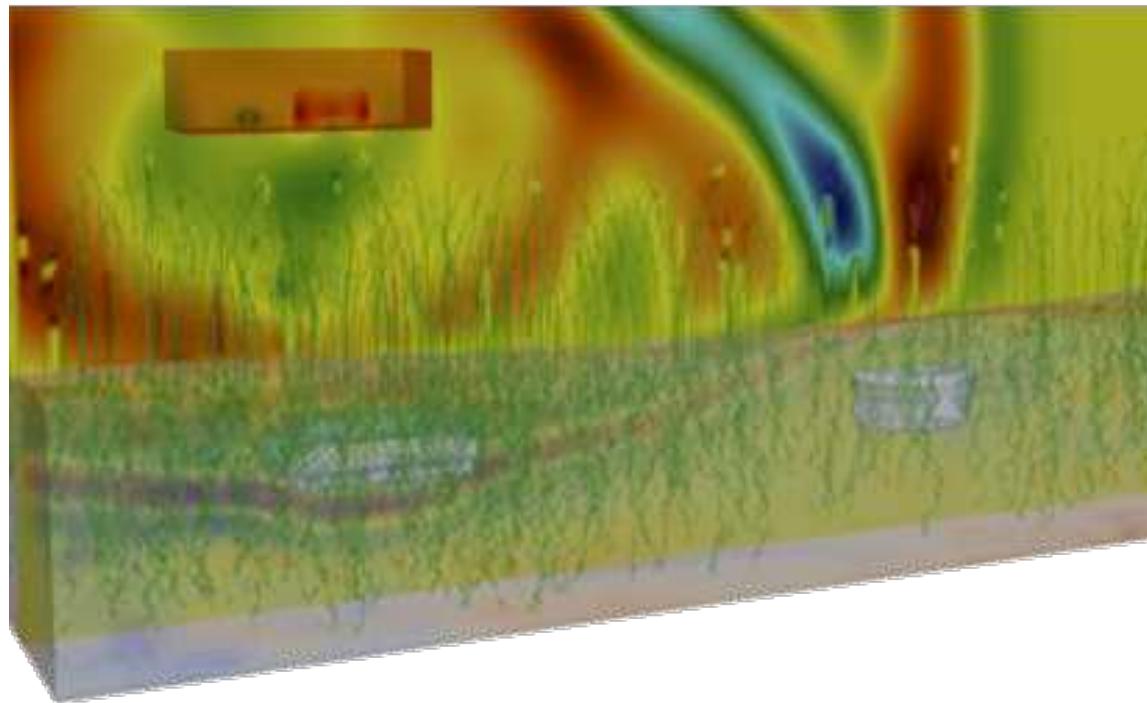






Landmine or Coke Can?

UAV Based Ground Penetrating Radar



Credits: Patrick Carson (UCL), Max Jacobs (Skycap)

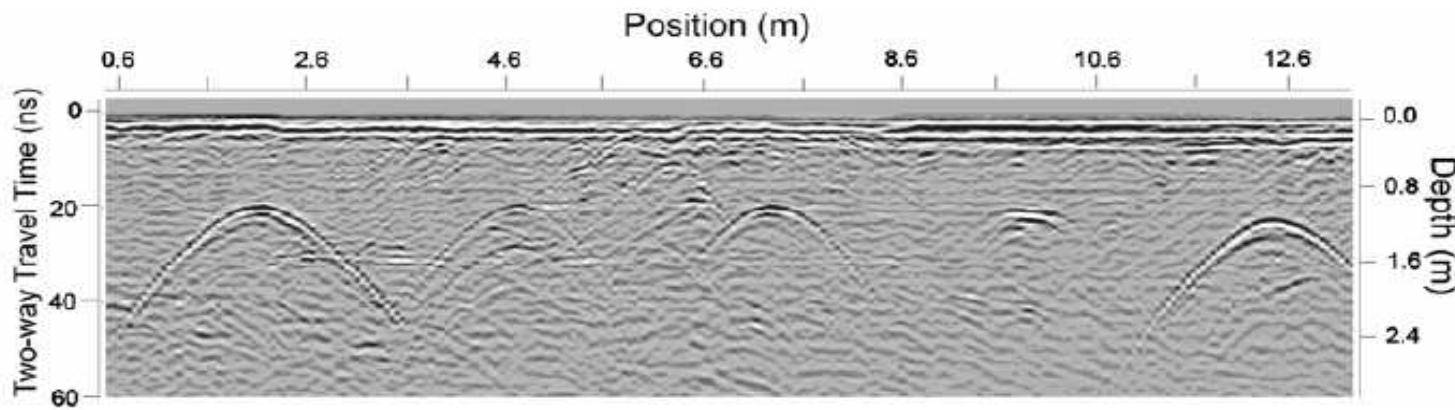
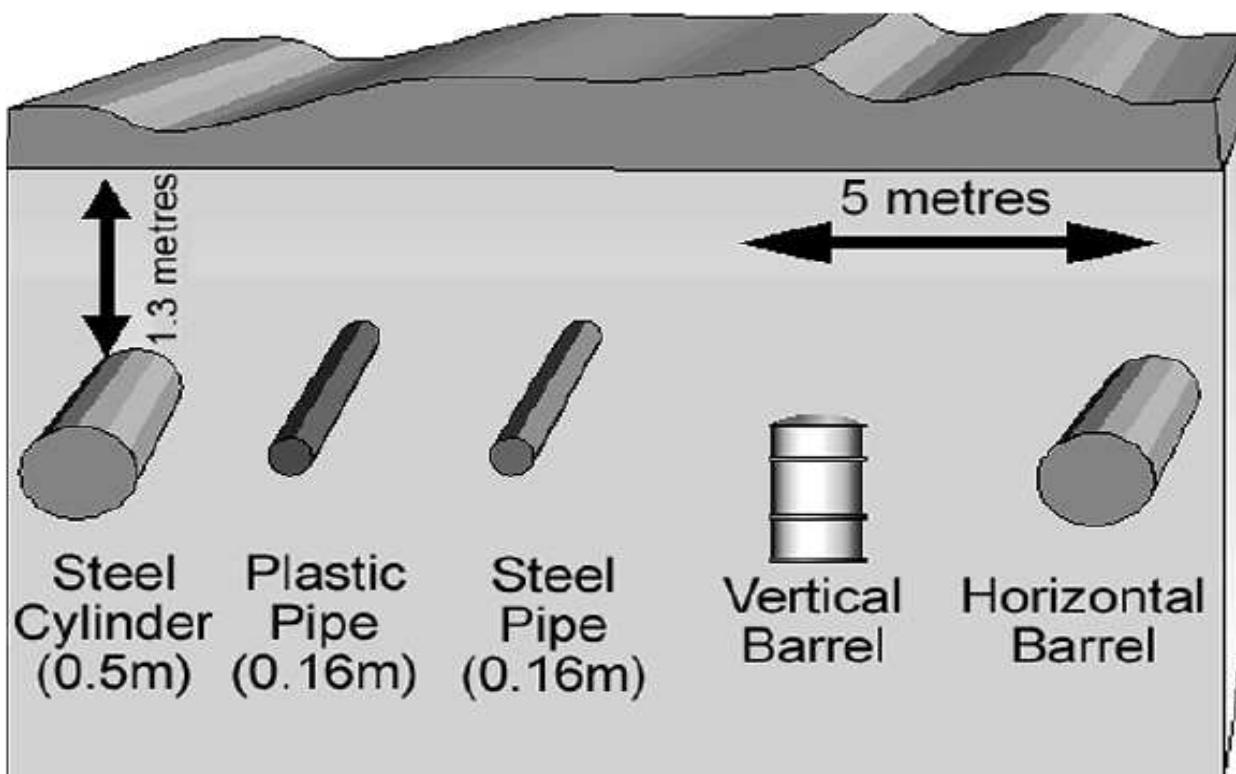
GPR: Hardware



How Does It Work?



How Does it Work

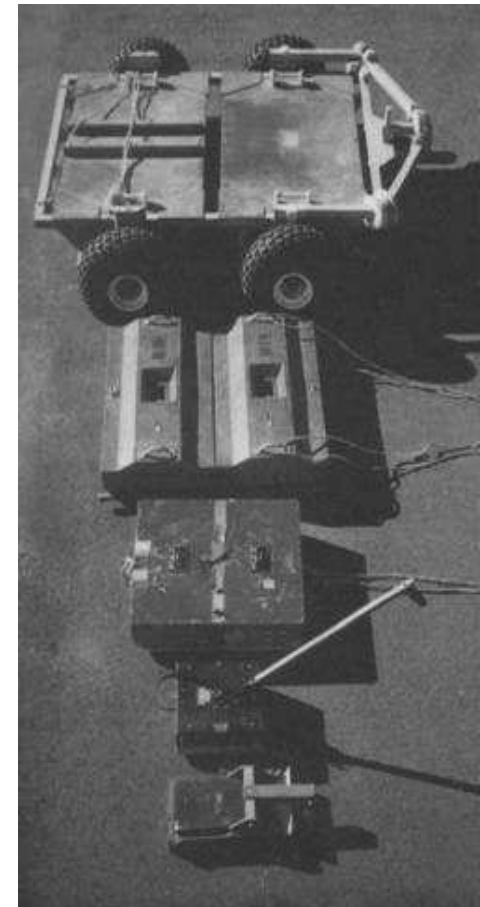


GPR != Magic

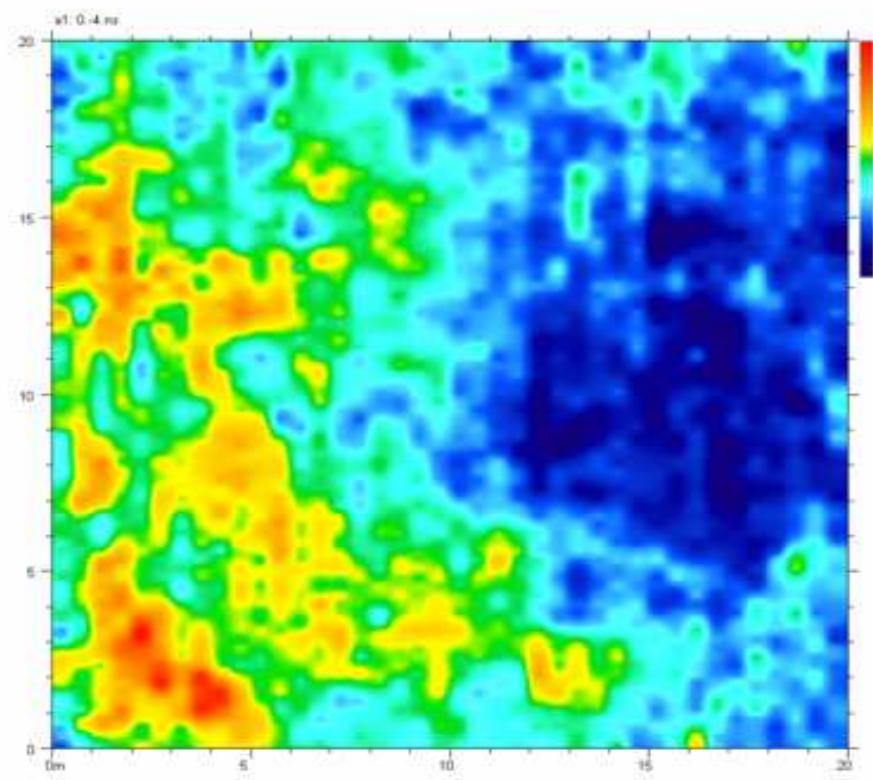
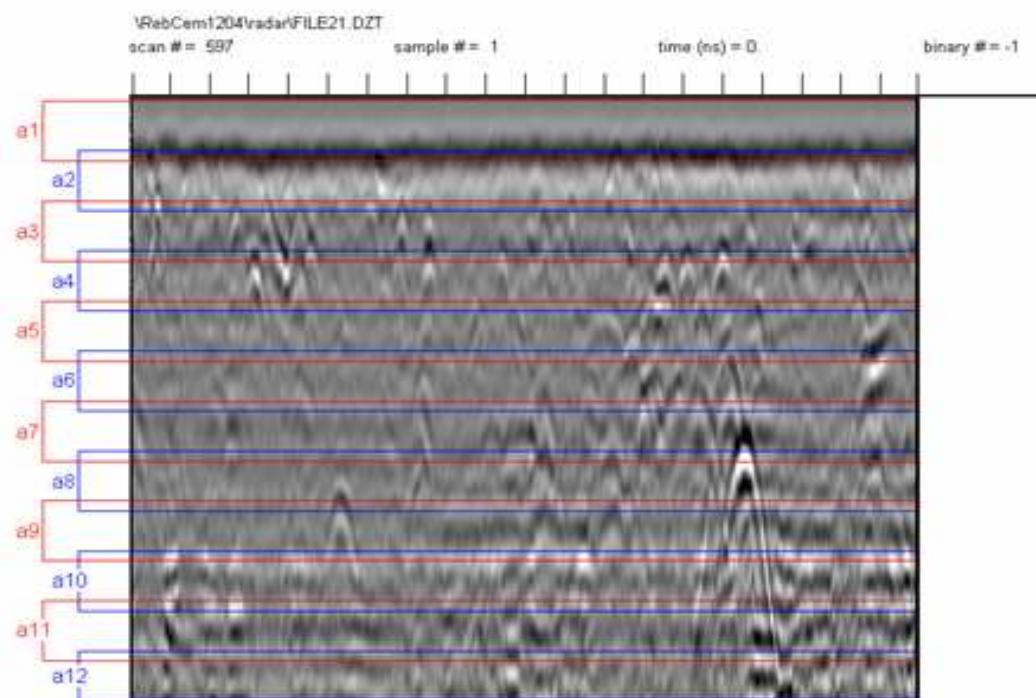
- Relative Dielectric Permittivity (RDP)
 - $RDP(\text{material}) = (c / V)^2$
 - c: speed of light in a vacuum (3×10^8 m/s)
 - V: velocity of radar wave through the material
- Ranges from 1 (air) to 81 (water)
- Related primarily to water content of materials
 - Higher ϵ values mean less radar penetration (more attenuation).
- Also problematic:
 - Conductivity (σ) and Magnetic Permeability (μ)

Antennas

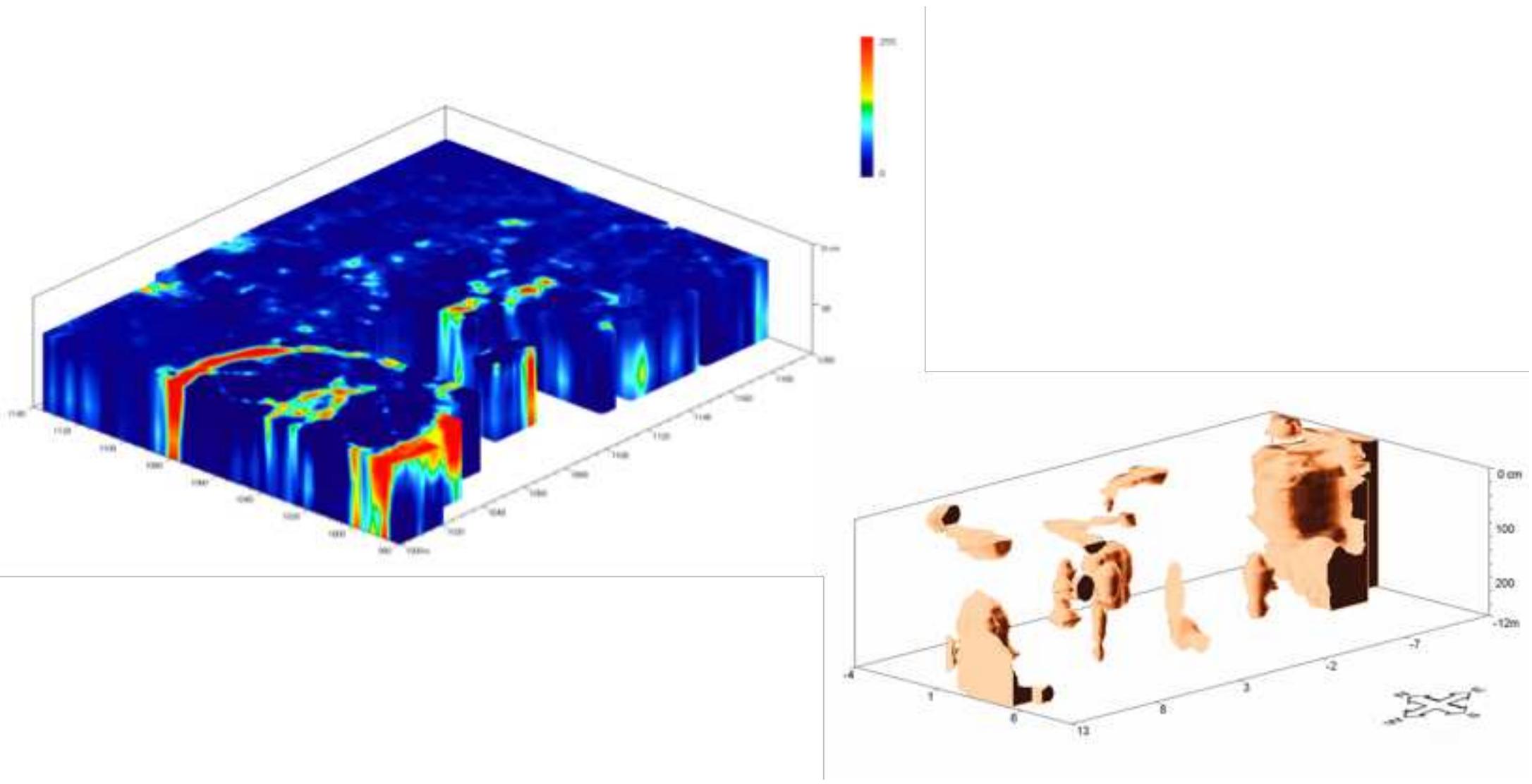
- Identified by center frequency in MHz
 - Higher frequency = greater vertical resolution
 - Lower frequency = greater penetration depth
- Typical penetration depths
 - 100Mhz 4-25m
 - 300Mhz 1-10m
 - 400Mhz .5-4m
 - 500Mhz .5-3.5m
 - 900Mhz 0-1m



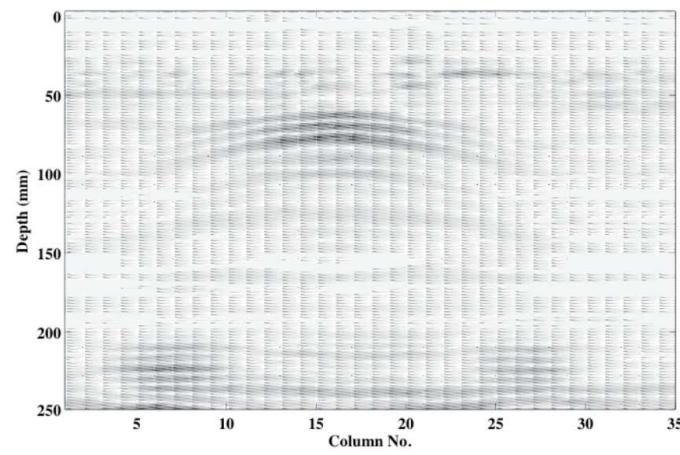
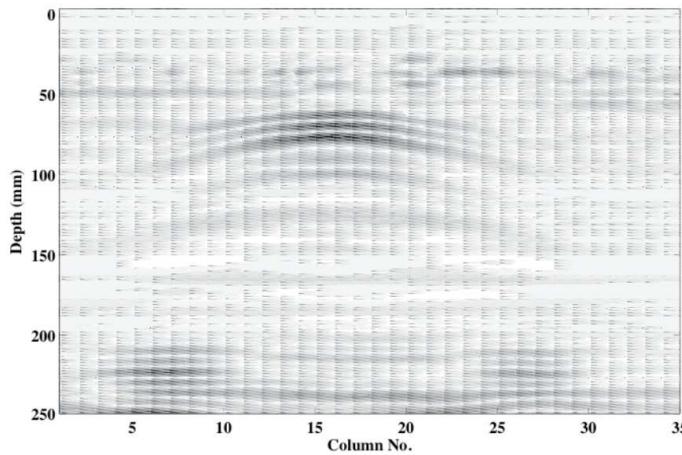
Birds Eye View



3D Data Cubes & Feature Extraction



Mine detection



Mine Detection



Airborne GPR

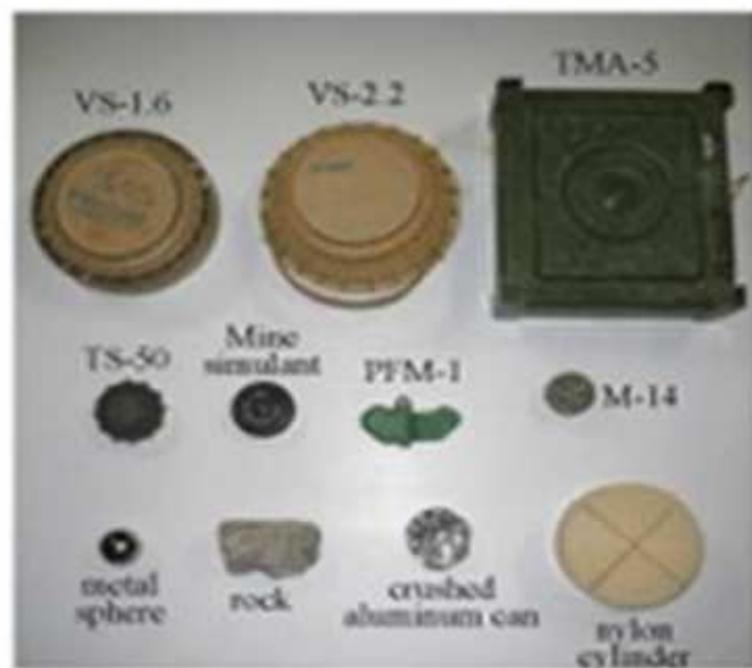
- Traditionally GPR antennas are ground coupled
 - Terrain can be problematic
- Airborne Antennas attractive but compromise on penetration
 - Still useful for certain applications
- UAV based GPR system



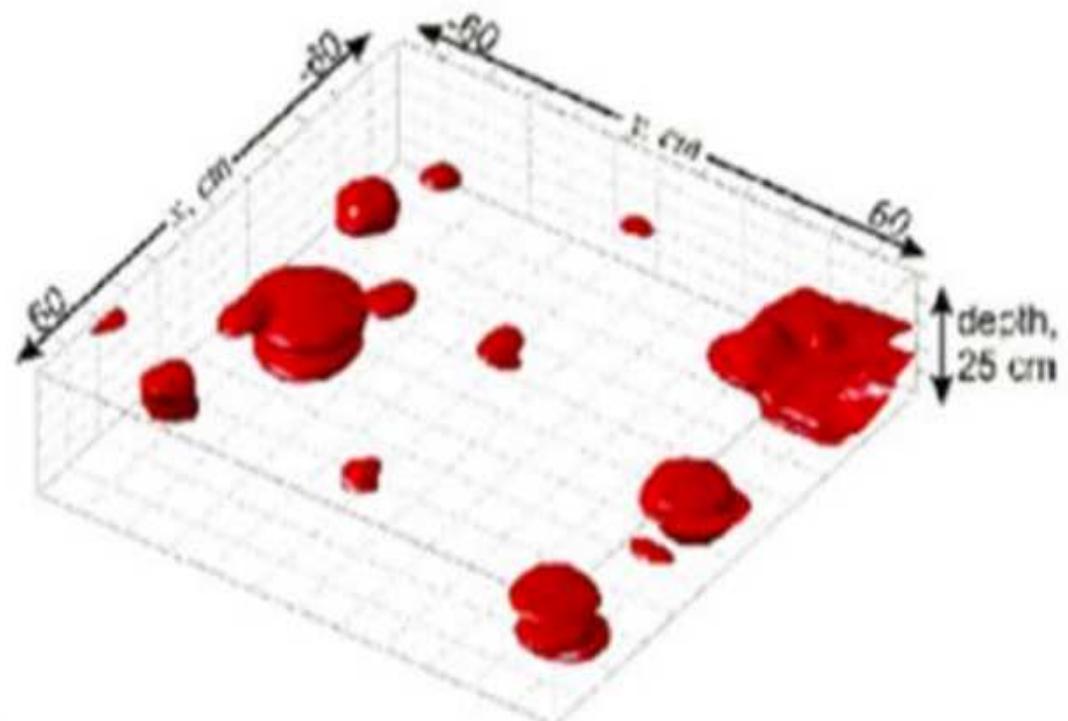
Aim



Aim



(a)



Could Drones cure disease?

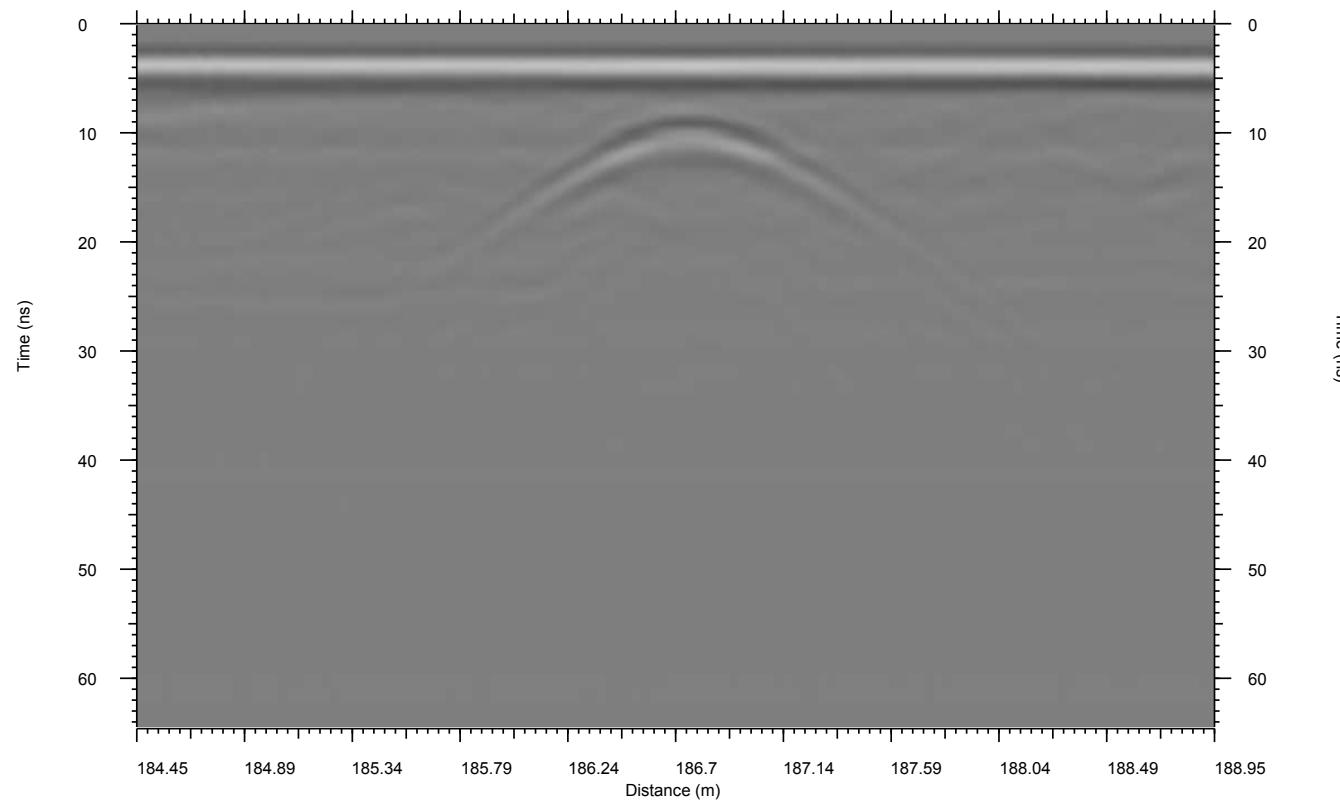
Andreas Raptopoulos, the owner of Matternet, is on a mission "to redefine how we transport things around us."

Case Studies



Ideal

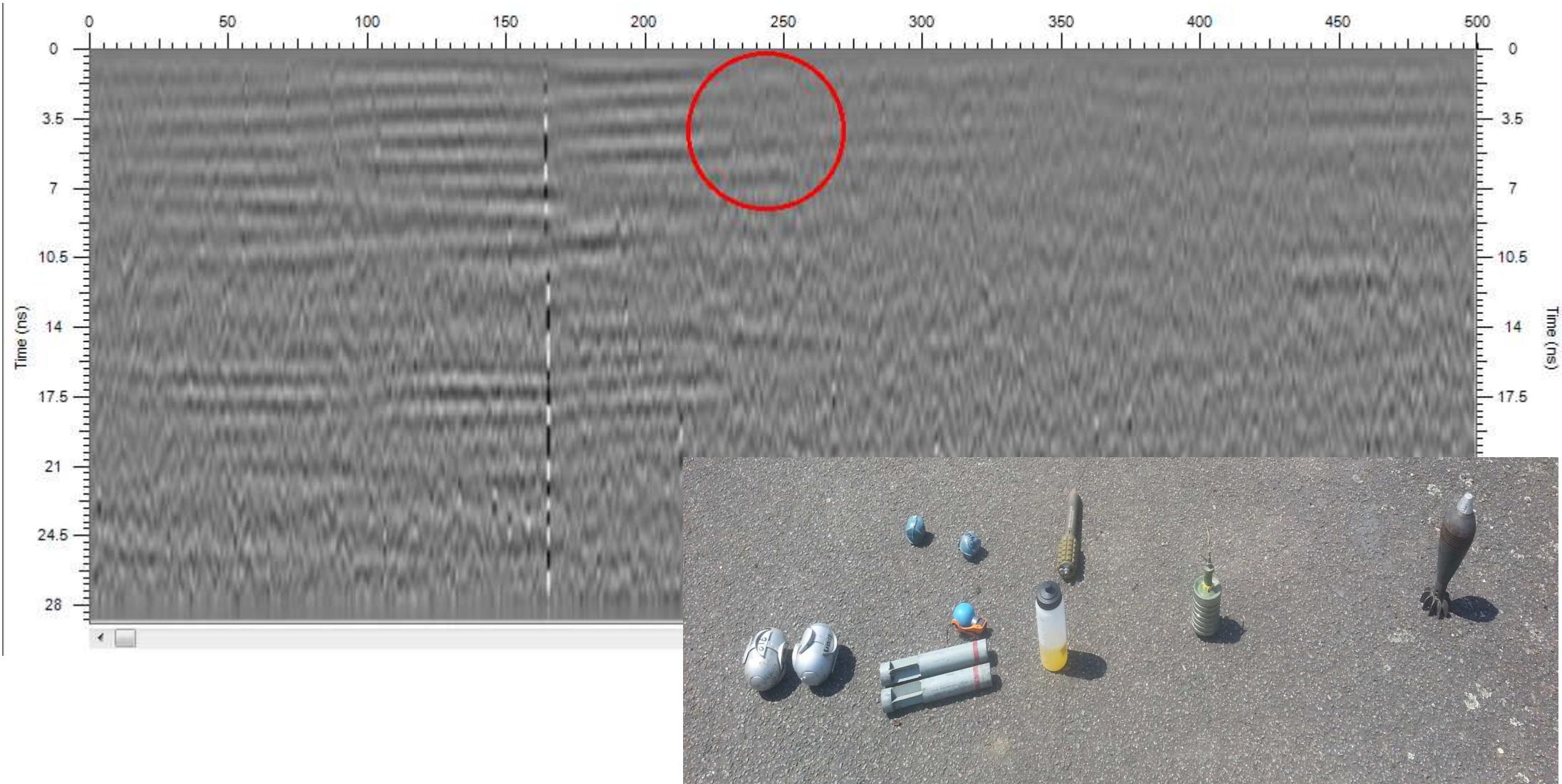
1Ghz scanner when in Sweden_ Large Gas Pipe



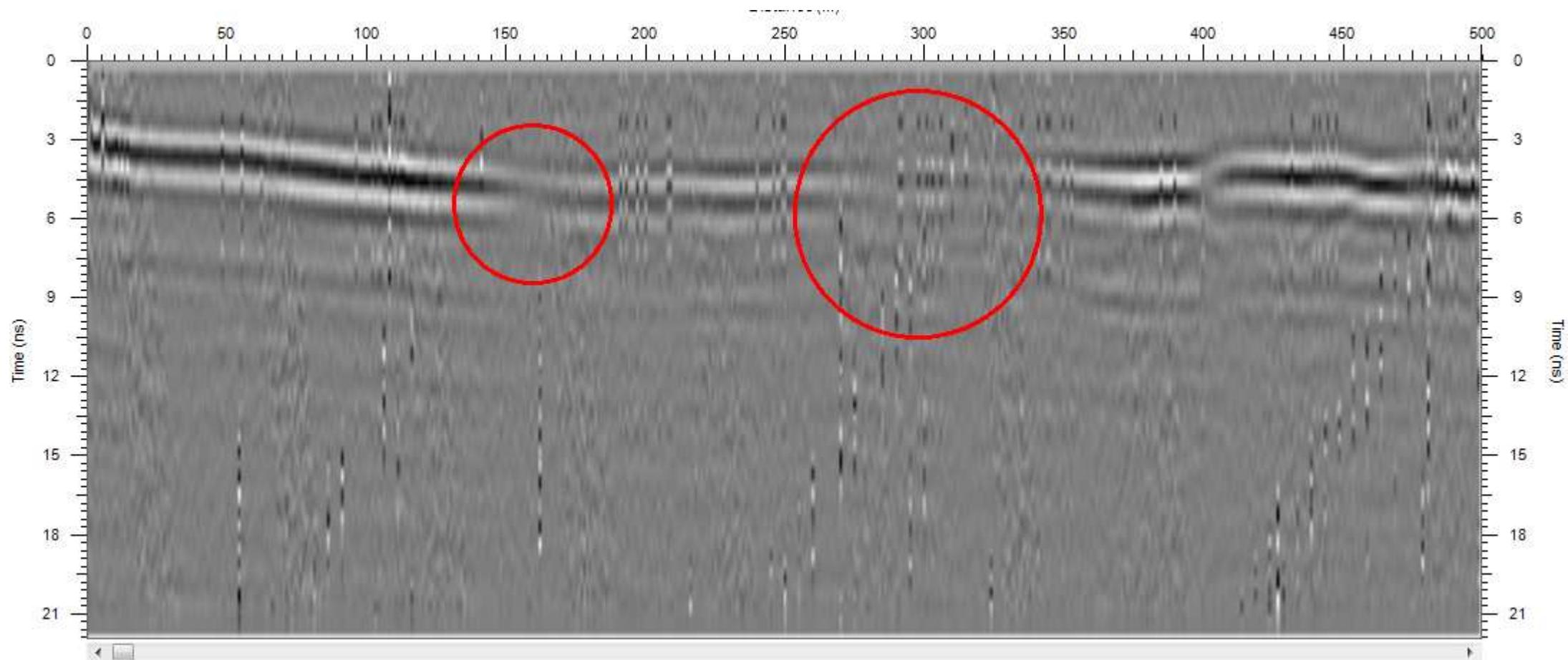
Profile336.gsf

1

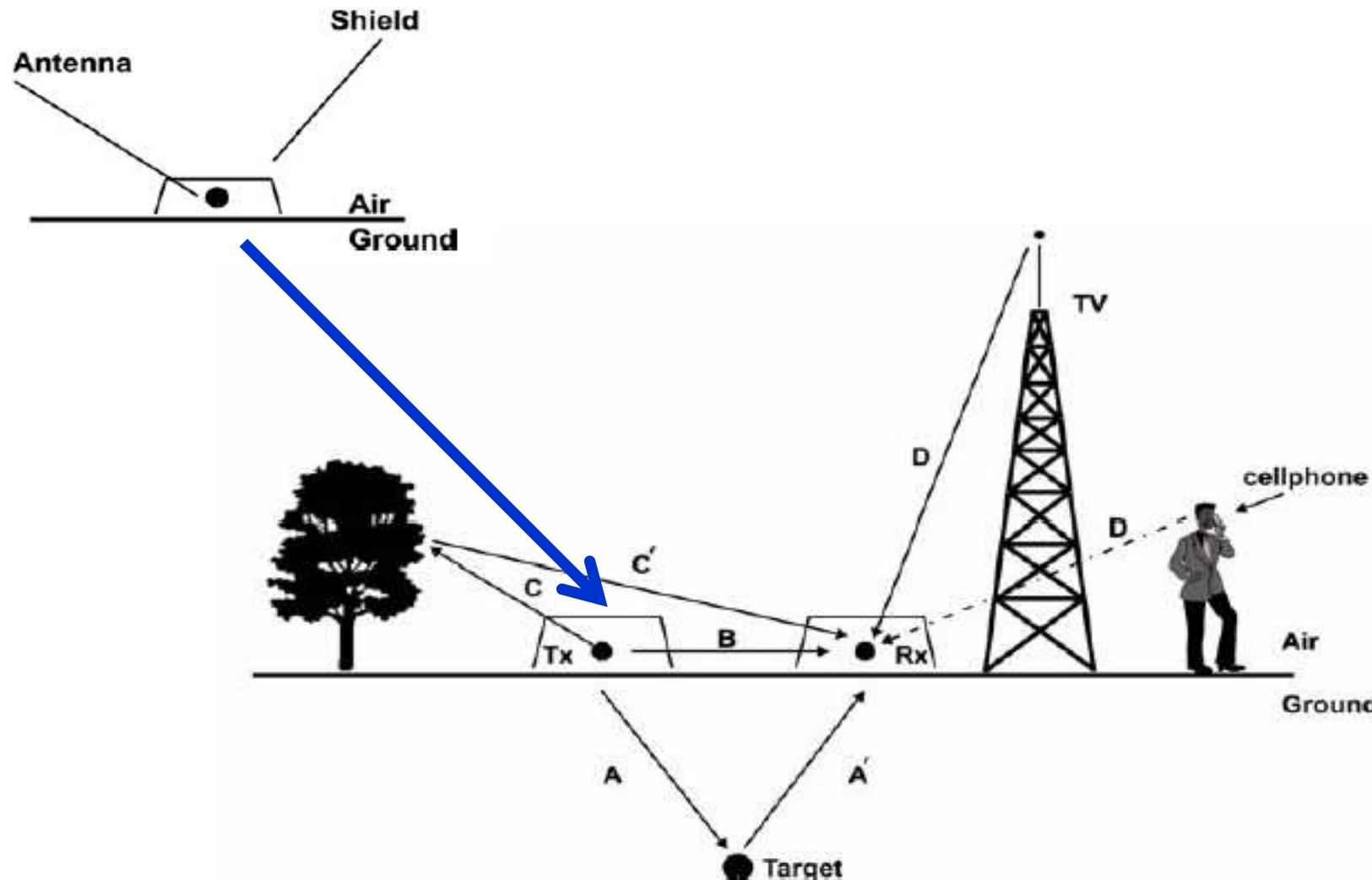
Reality



Reality

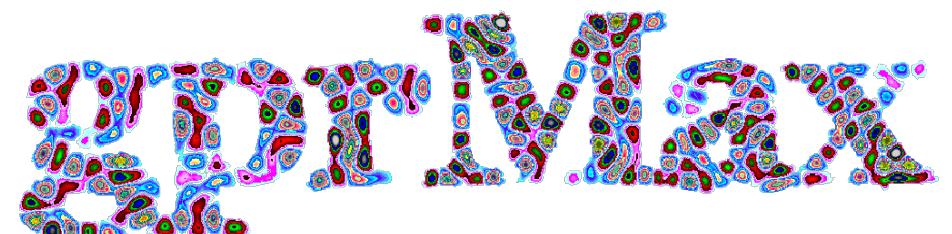


Interference

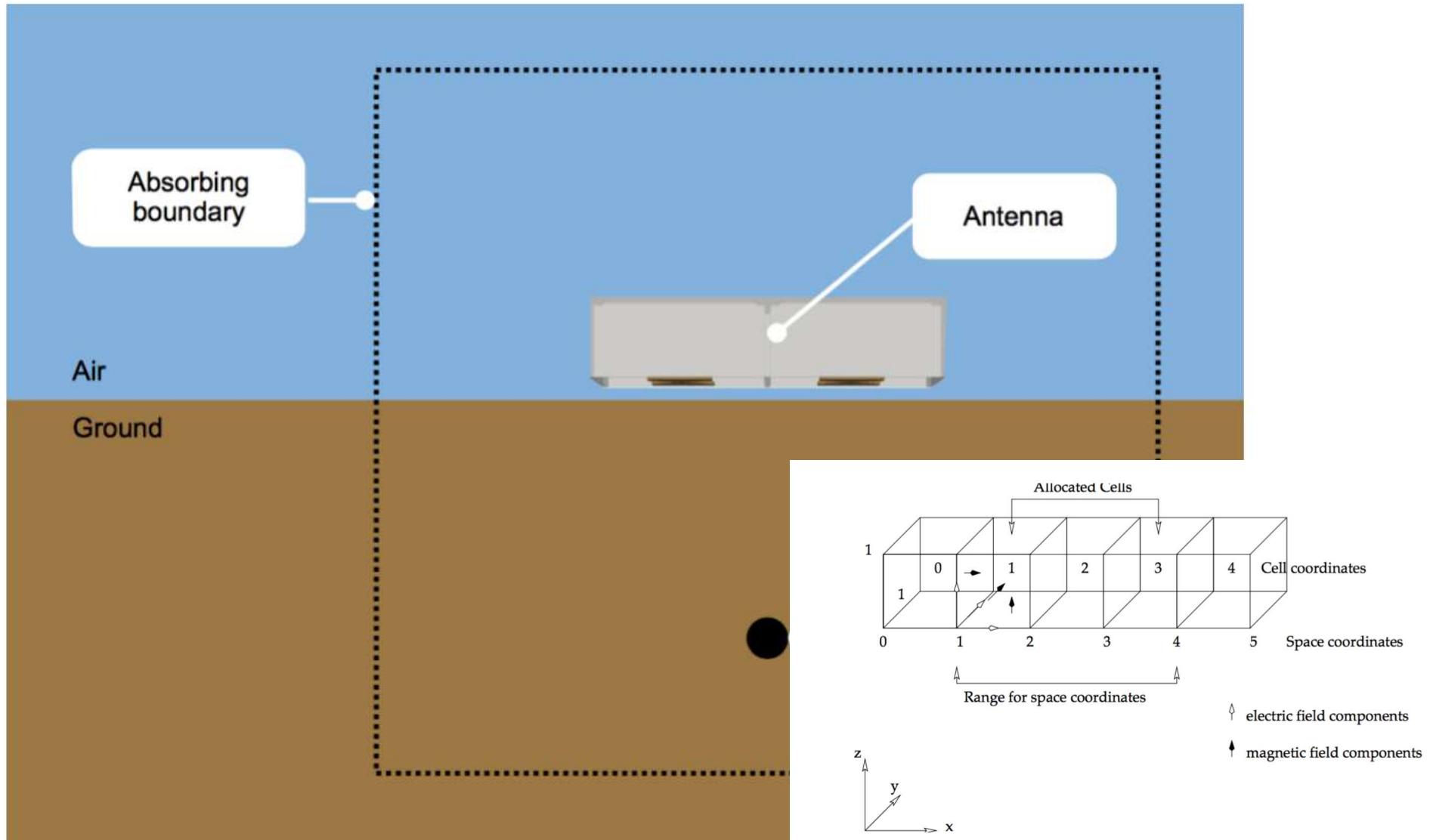


Machine Learning

- Landmine detection from GPR data an old and well studied problem
 - Hard!
 - Significant human expertise
- Leverage recent advances in machine learning?
 - Provide decision support
 - Never replace human operator
- Need labeled data
 - => Simulation



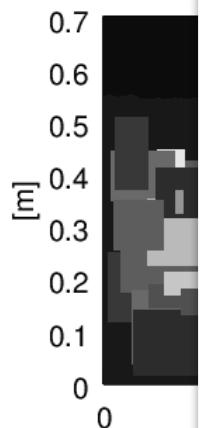
GPR Max



Machine Learning Pipeline

Define variation

Gen
gprN



numpy

scipy

matplotlib

scikit-learn

pycaffe

train
no /
ts

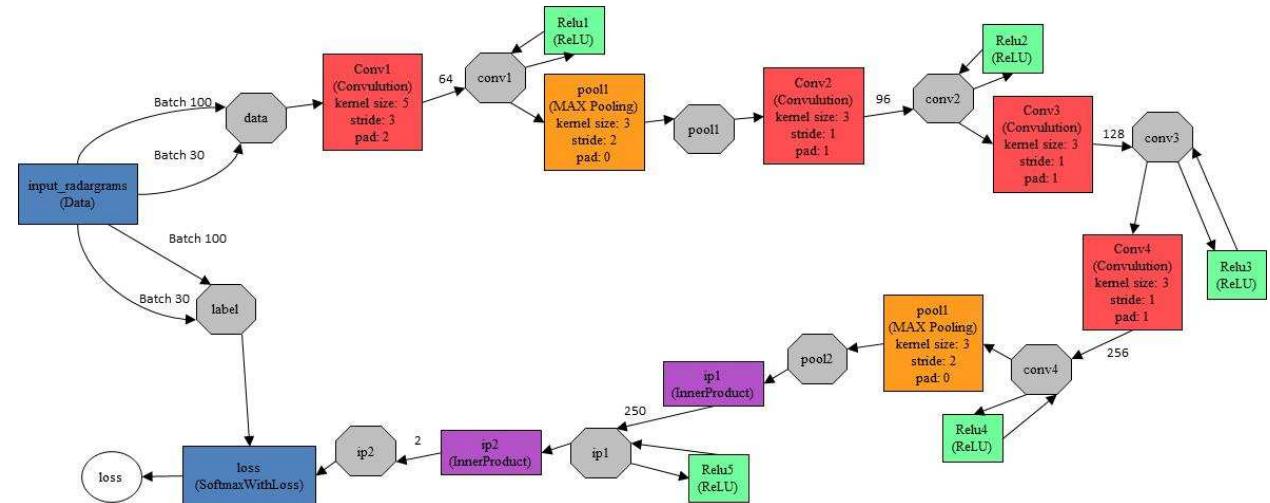
Apply
classifier



...

Machine Learning

- Fundamentally a supervised machine learning problem
- Many classifiers exist
- Here, treat as a vision problem
- Convolutional Net



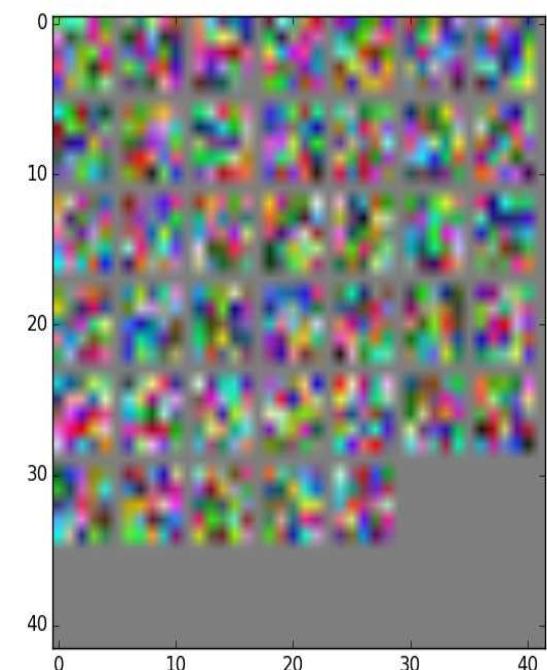
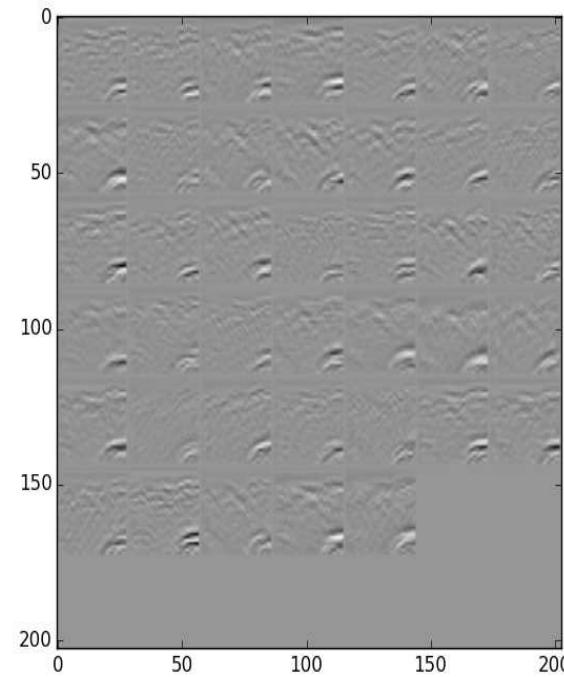
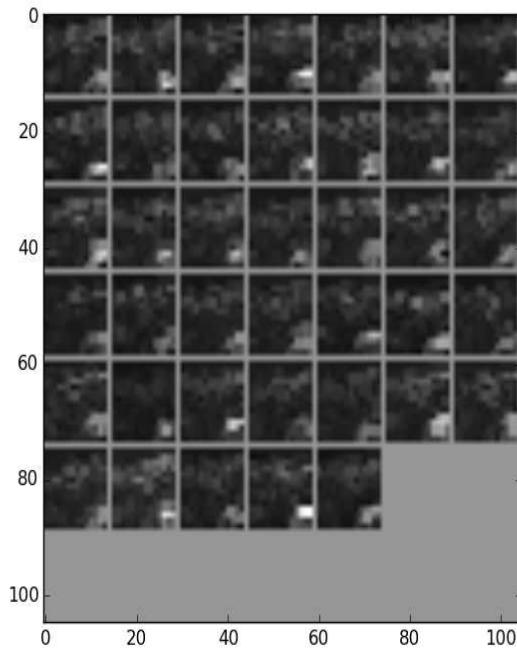
Easy Dataset



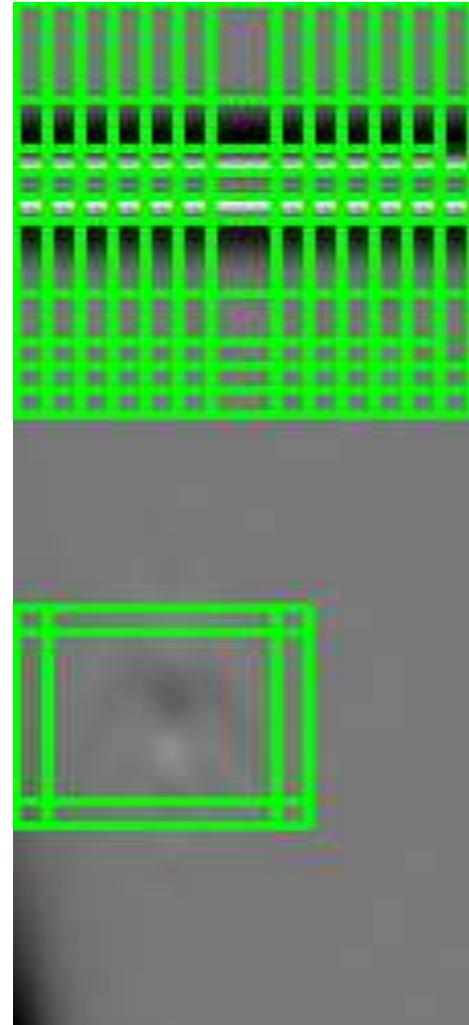
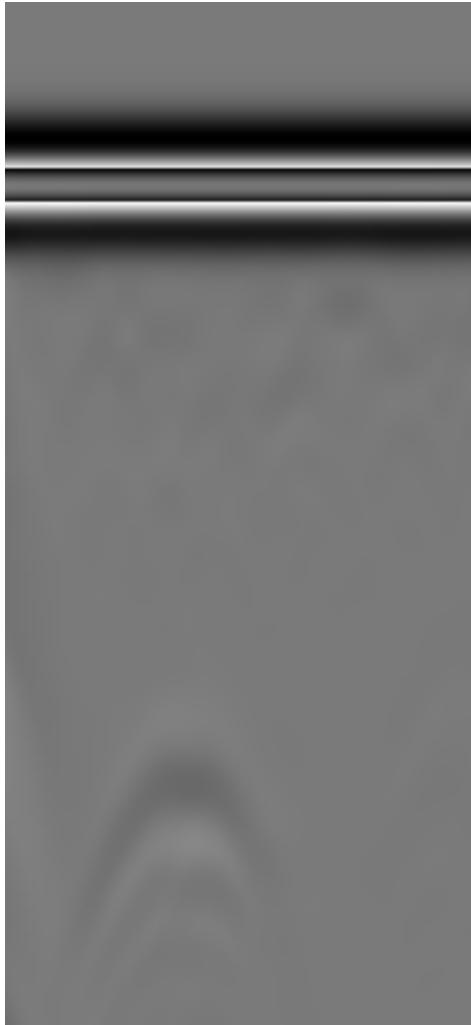
Medium / Hard Dataset



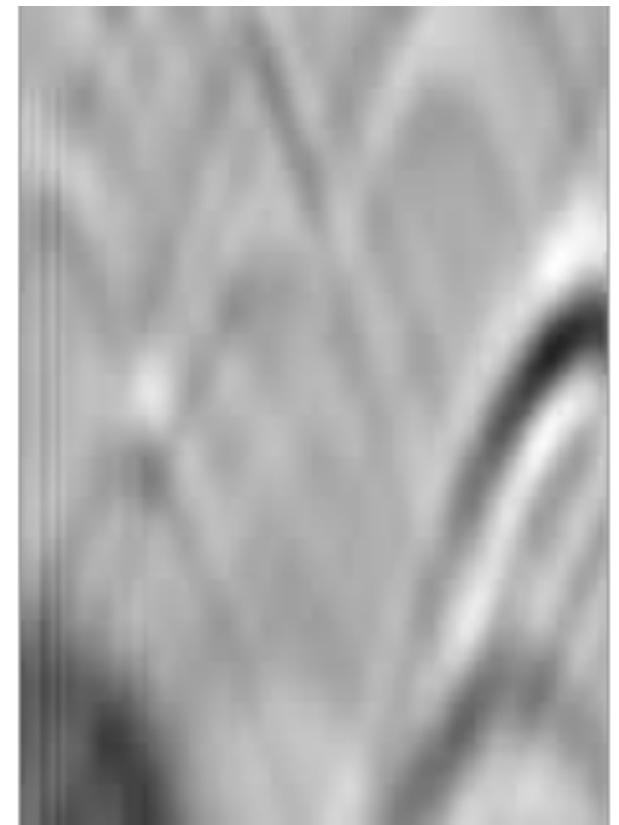
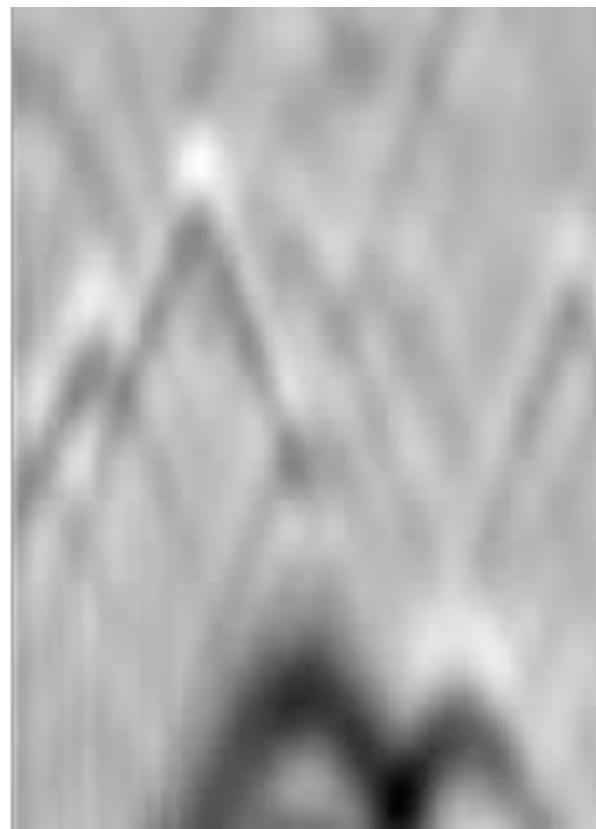
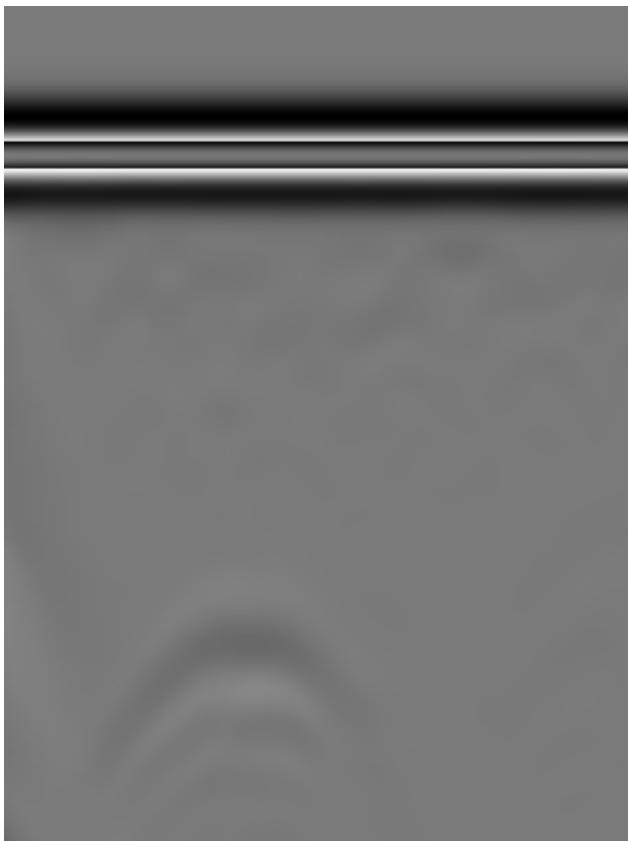
Convolution Filters



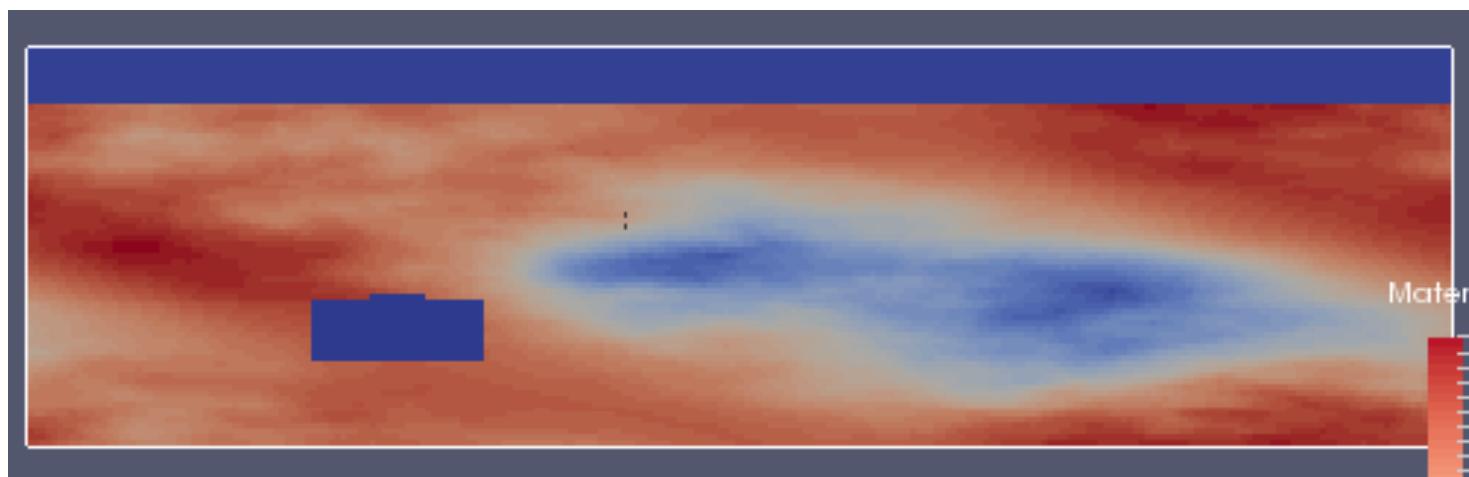
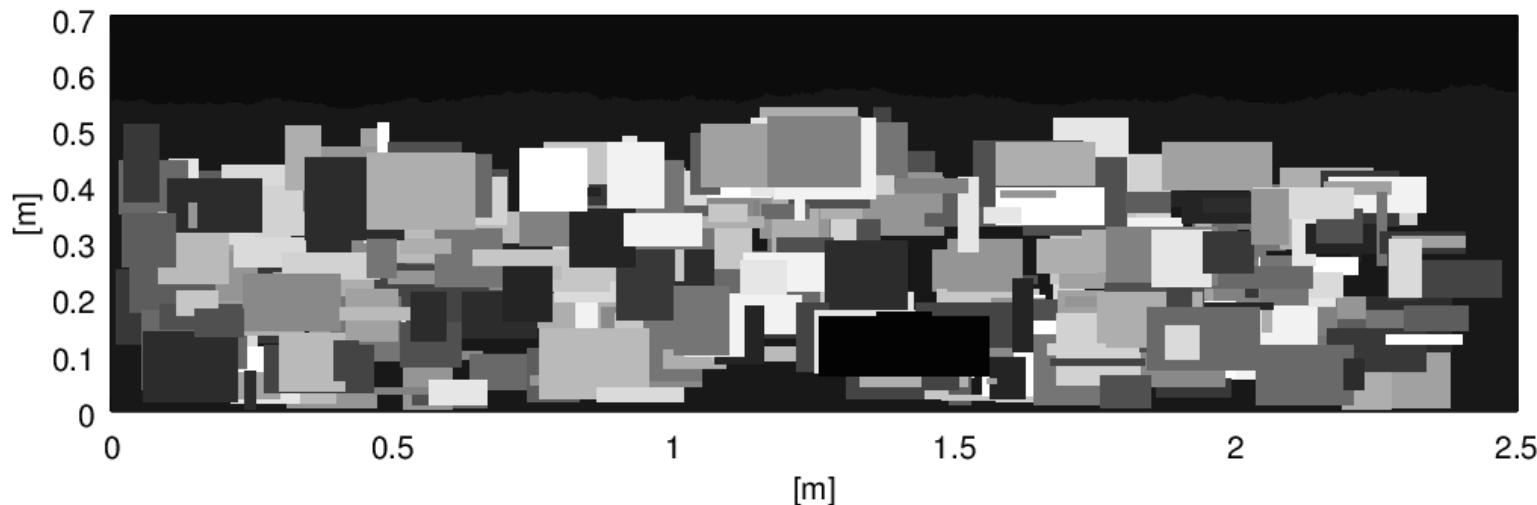
Localisation



Band-cutoff



New gprMax Version





Open source | Finite-Difference Time-Domain
Electromagnetic modelling software

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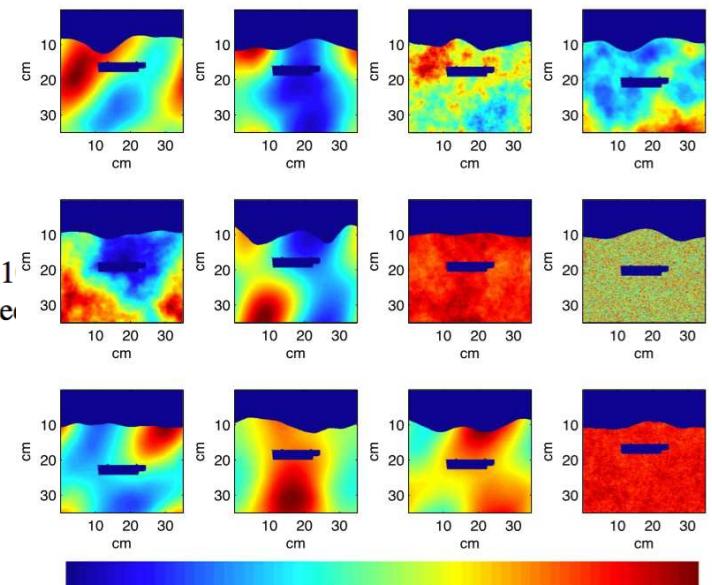
oc. 8th Int. Workshop

Model-Based Evaluation of Signal-to-Clutter Ratio for Landmine Detection Using Ground-Penetrating Radar

Iraklis Giannakis, Antonios Giannopoulos, and Alexander Yarovoy, *Fellow, IEEE*

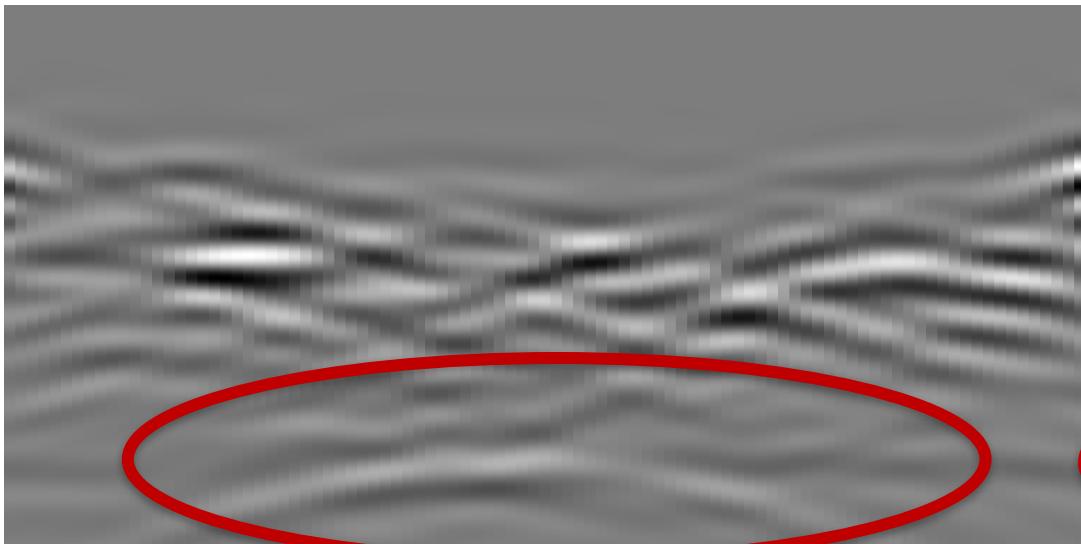
stract—A regression model is developed in order to estimate at time the signal-to-clutter ratio (SCR) for landmine detec-

[8], artificial noses [9], and acoustic methods [1] context, ground-penetrating radar (GPR) has been

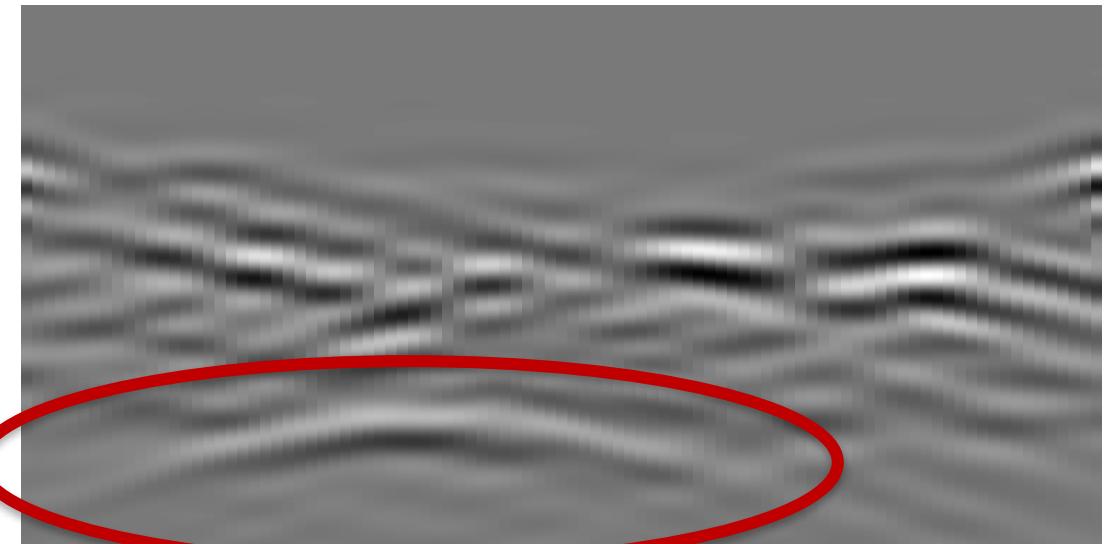


New Dataset

- 1000 examples -> 2000
 - ~ 90 minute simulation time
 - Still very high accuracies (> 90%)

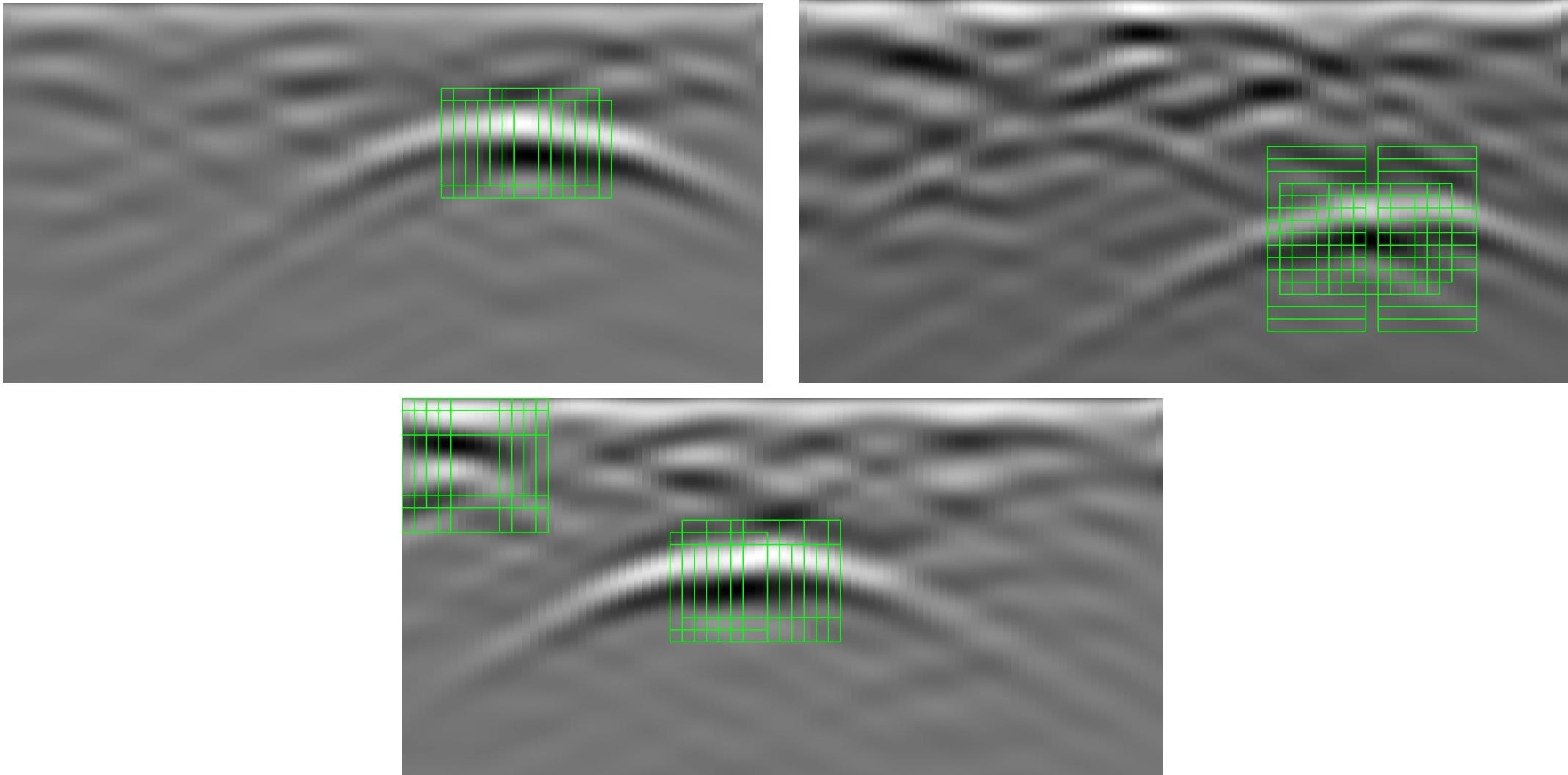


False Negative



True Positive

Localisation



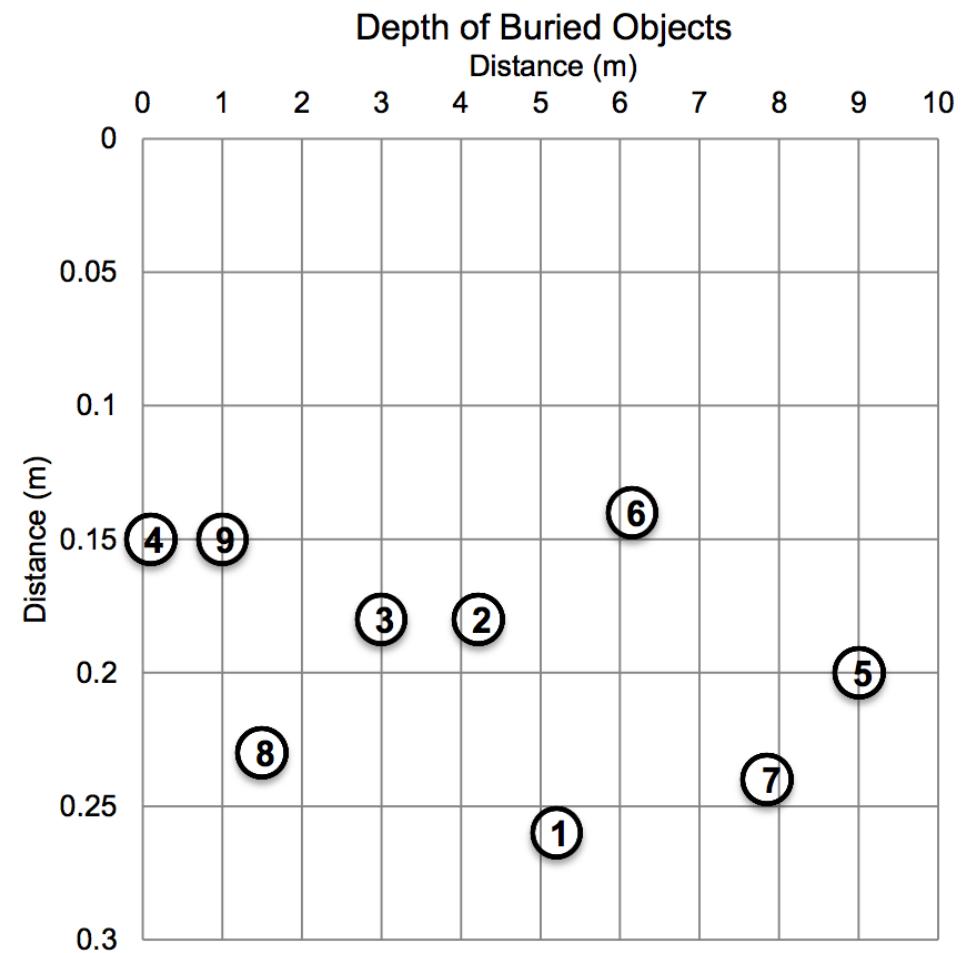
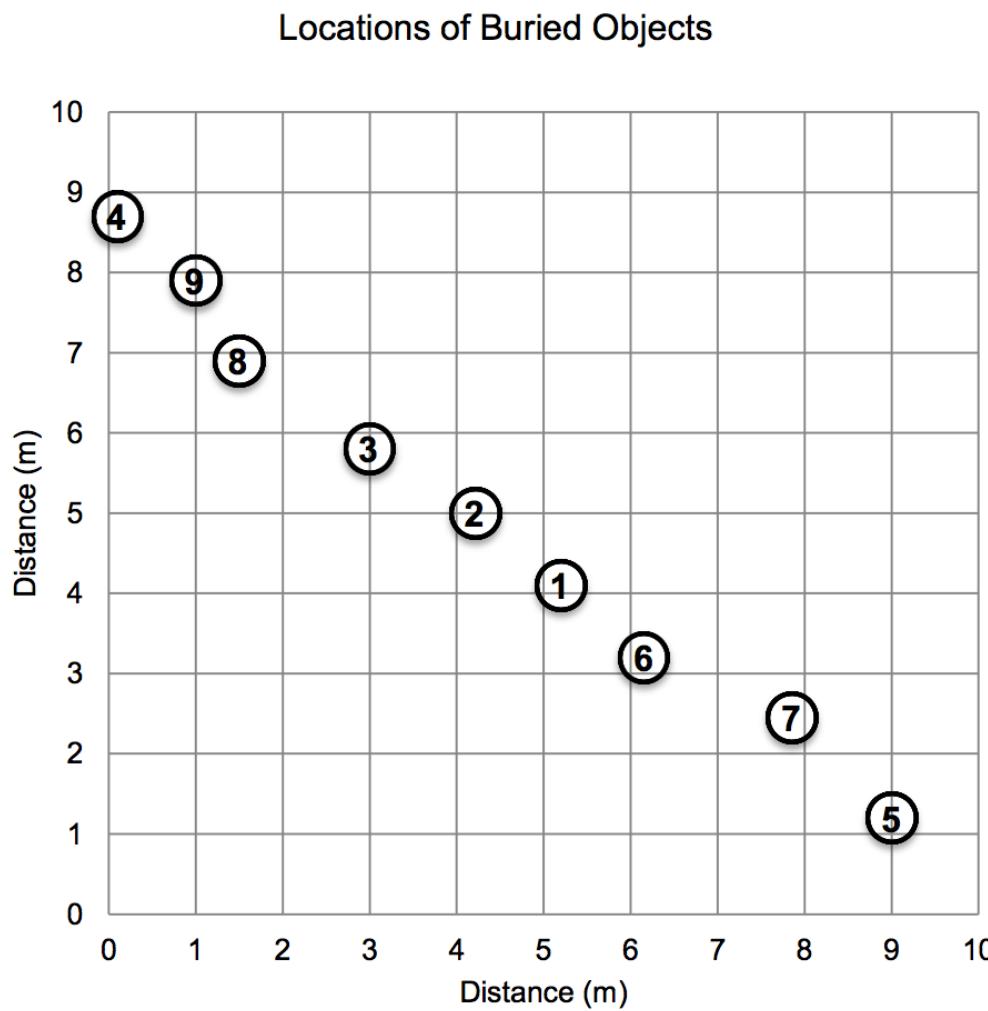
UAV Based GPR



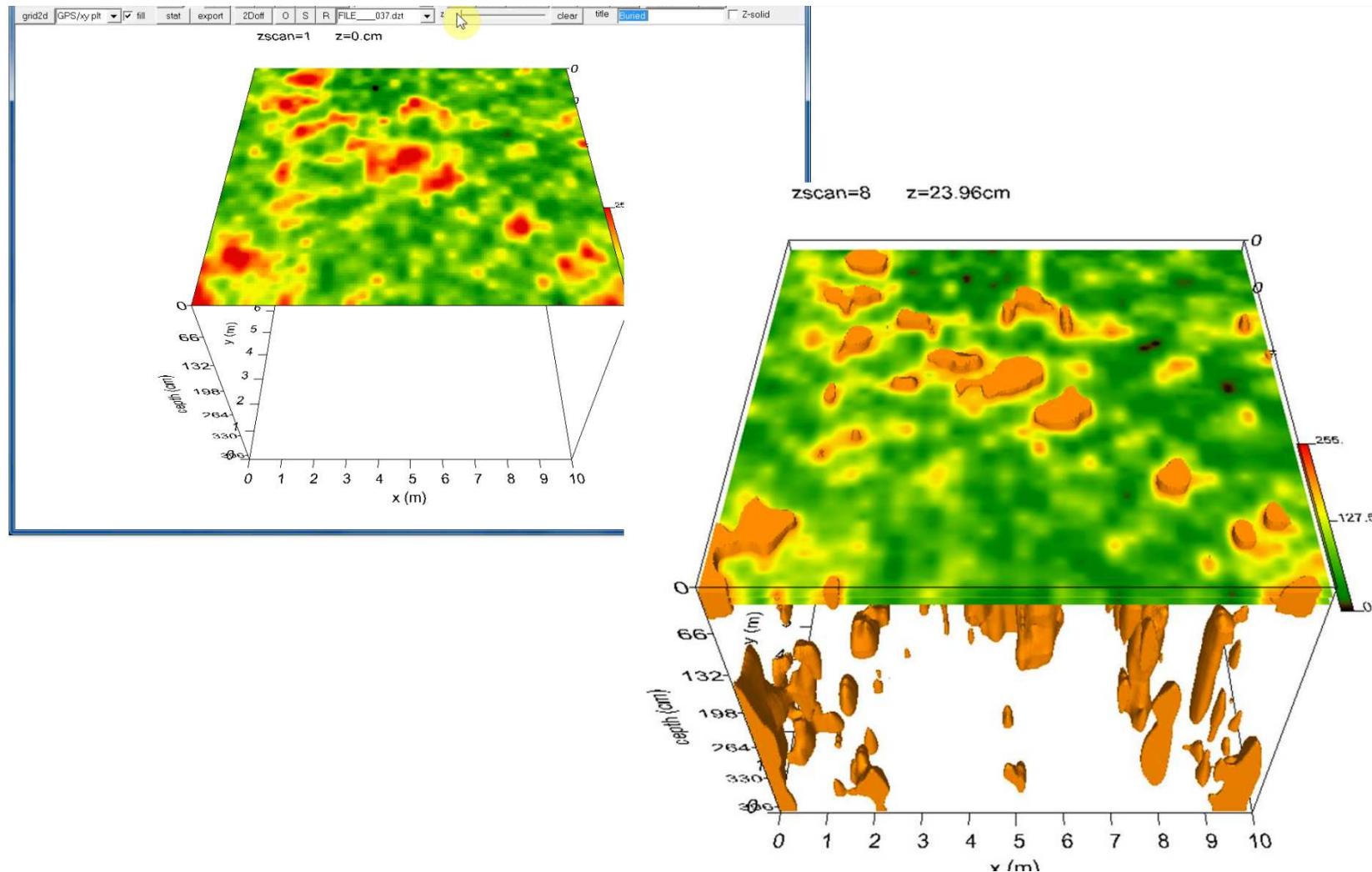
Data Collection



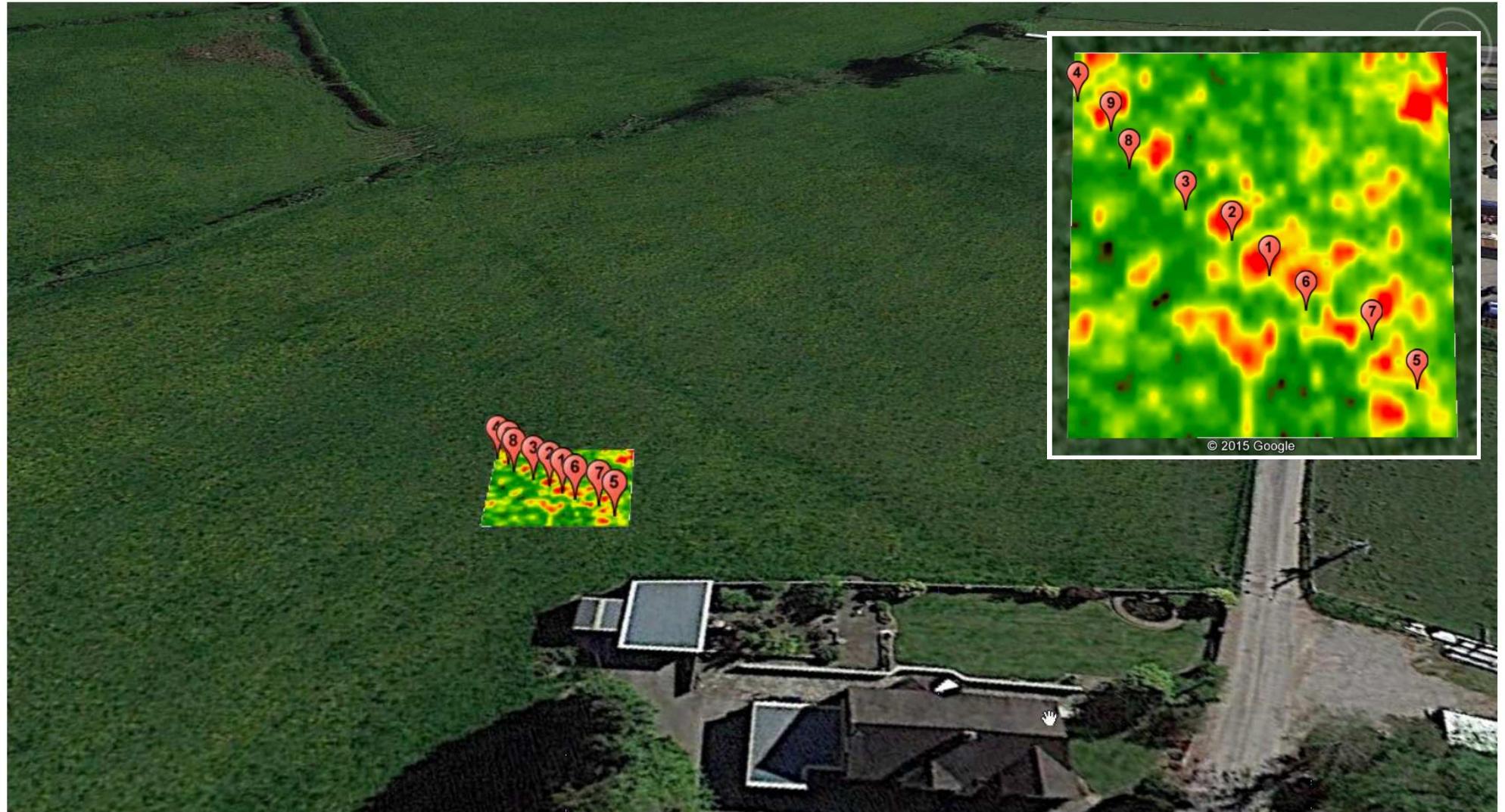
Data Collection



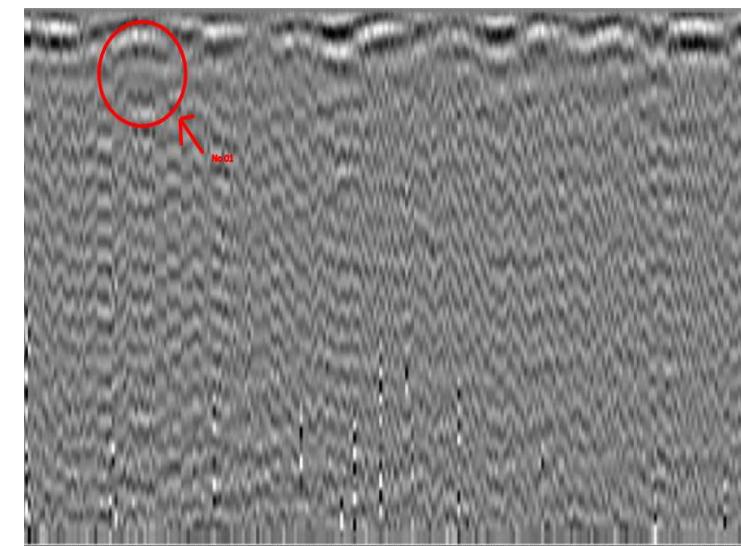
Data Collection



Data Collection



Data Collection



Machine Learning?



Future Work

- More realistic datasets & sophisticated models
 - Field Tests!
- False positives vs False negatives
- Machine Learning on Birds-eye-view and 3D
- Improved object localization
 - Multiple object detection (RNNs?)
- Active learning & integration of human expertise
 - Probabilistic approach?











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Post Release Monitoring of Orangutans

- Goal:
 - Monitor released OU movement, health & general wellbeing
- Most intensive first 2-3 months, tapering off over 2-3 years
- Problems
 - Very human intensive to keep track of their movement
 - Once lost track, how to find them?



Implants

- Ideally external attachment but non-trivial
=> Implants
- Pro
 - Small, minimally invasive (23min surgery)
 - No external attachment problems
 - 1-3 years battery life (12hr / day)
- Con
 - Invasive (11 days heal time)
 - Detect only
 - Leak / break
 - Can't change battery
 - Unreliable (18-30%?)
 - Range: ~100-400m



Localization: Ground



Localization: Air

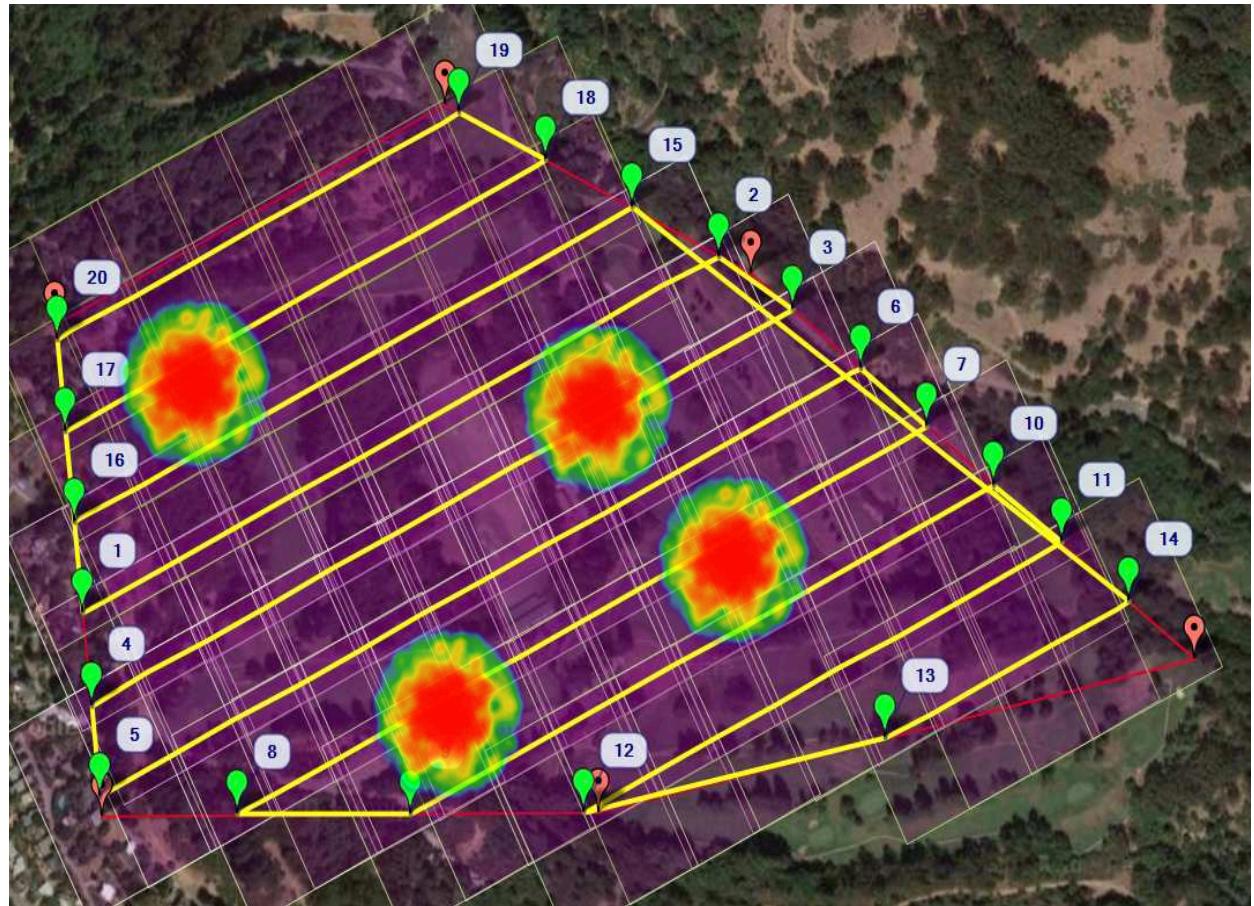
Drones

- Needle in haystack -> Needle in bale
 - NOT solving fundamental problem
 - NOT be-all-end-all solution
 - NOT going to save orangutans from extinction
- Given the current parameters, a useful approach
- Core problem is habitat destruction
 - Its complex
 - Its depressing

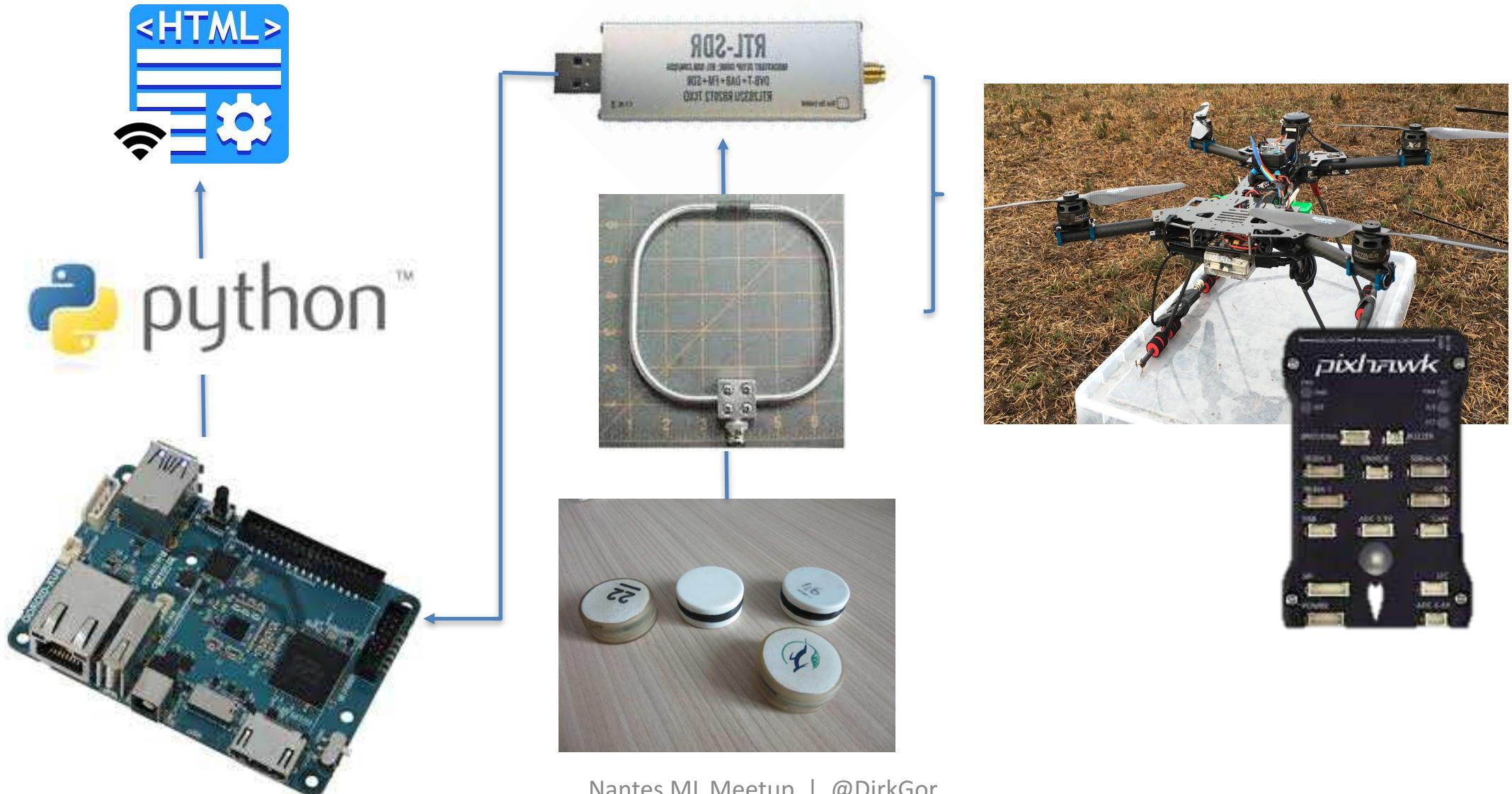


Operational Usage

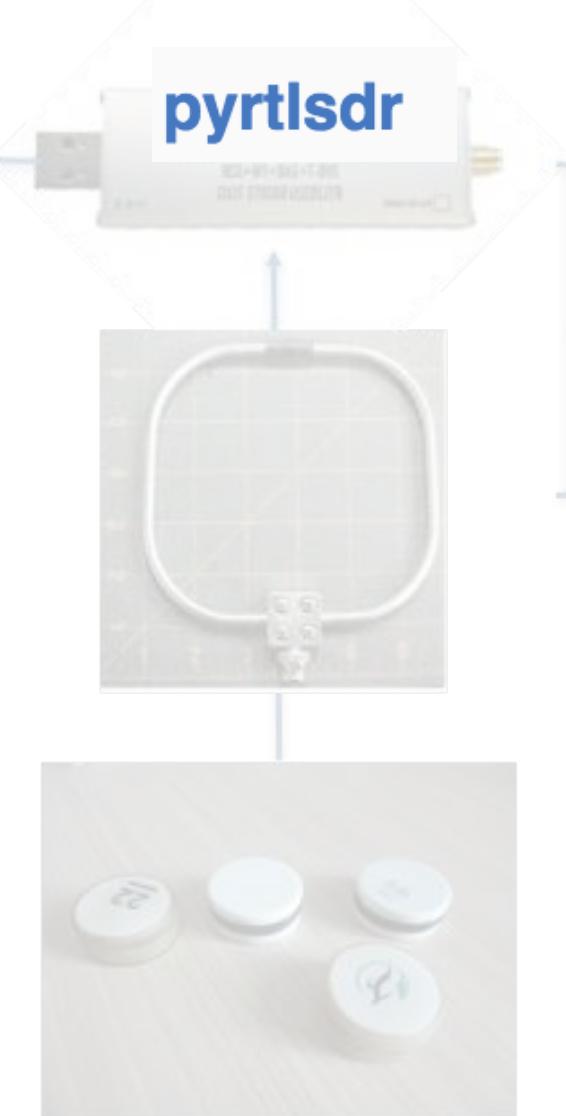
- Start simple
 - Pre-programmed flight path
 - Map signal strength
 - Estimate locations
- Pro
 - ‘Simple’
 - Naturally multi-animal
- Con
 - Inefficient



System Components

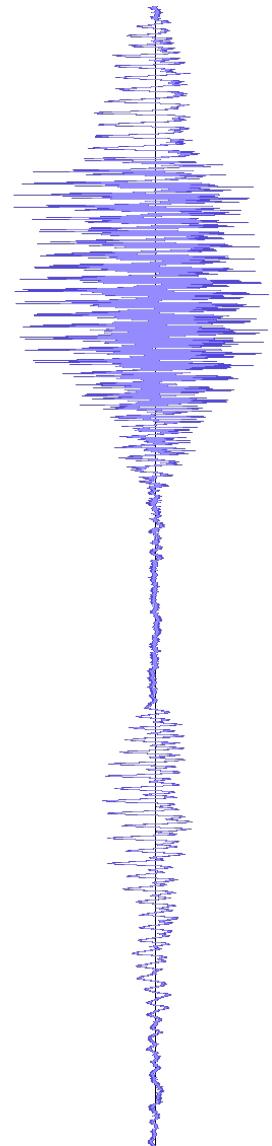


Programming Stack

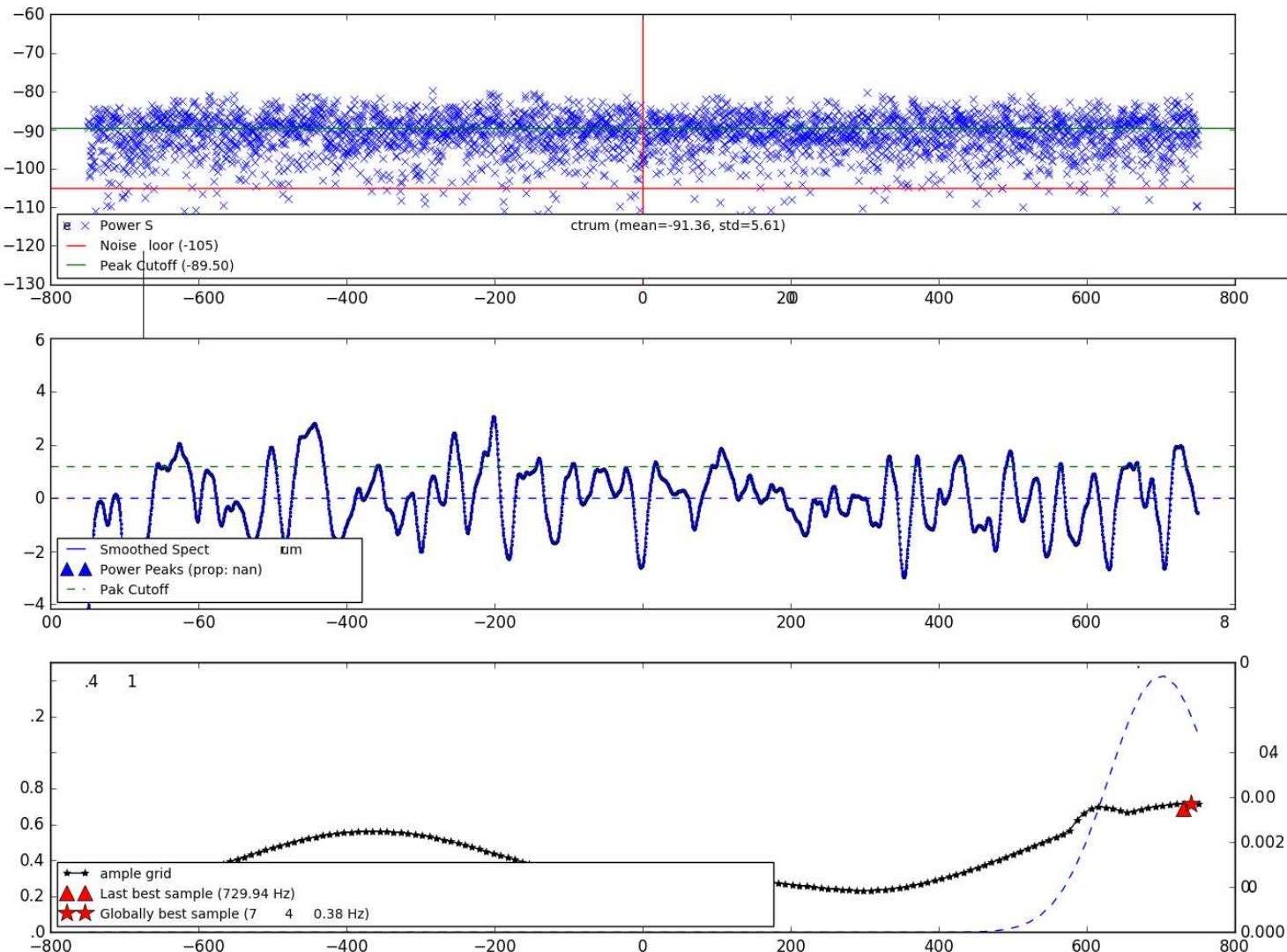


Detection Logic

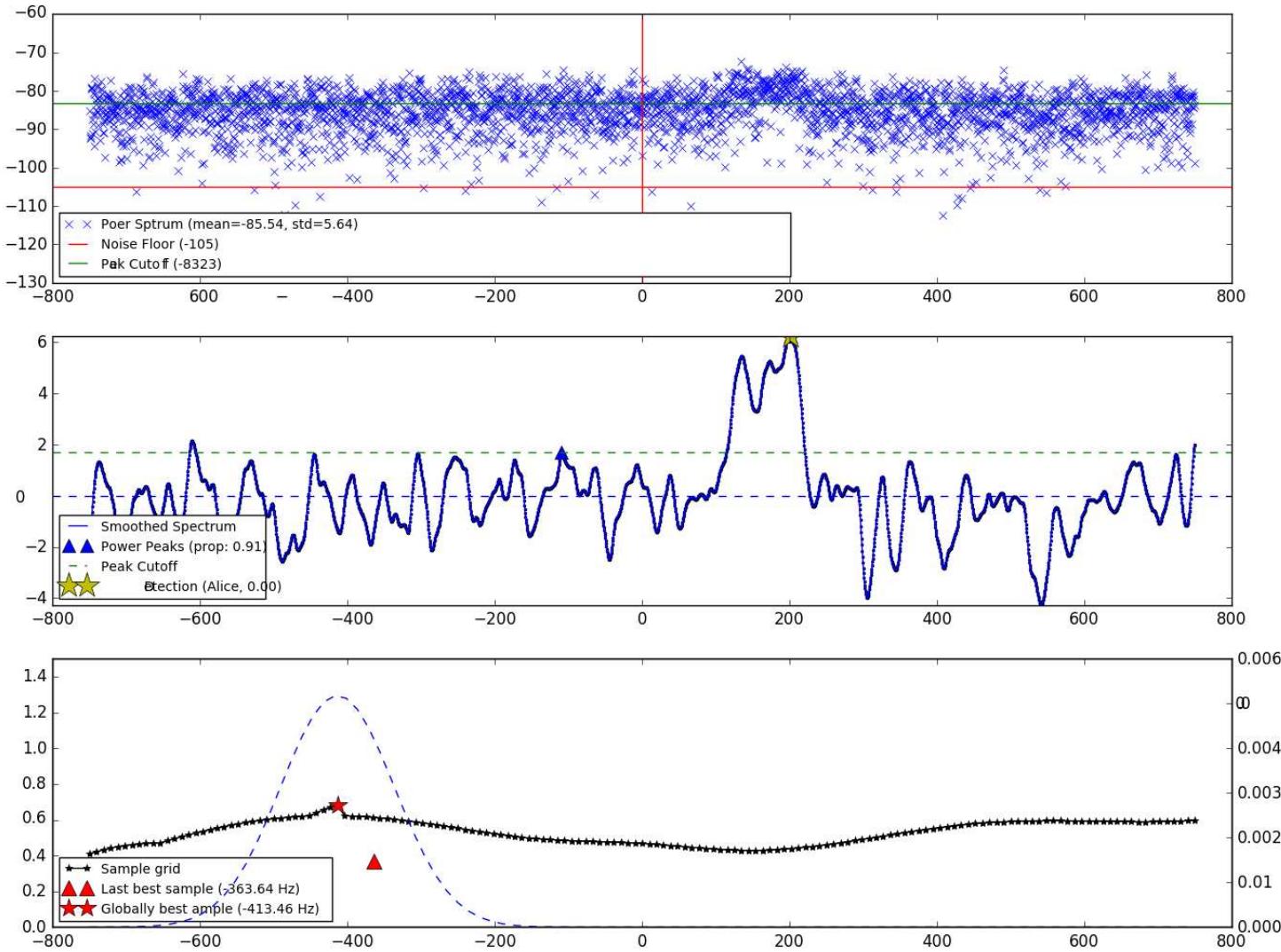
- Payload interaction through browser
- Loop
 - Collect batch of samples
 - Frequency domain peak detection
 - Time domain pulse detection
 - Log results & drone metadata
- Post process on landing
 - Operates fully offline
- Notes
 - Heuristic
 - Neither SDR / implant operate exactly at the specified frequency
 - Need to operate in real time



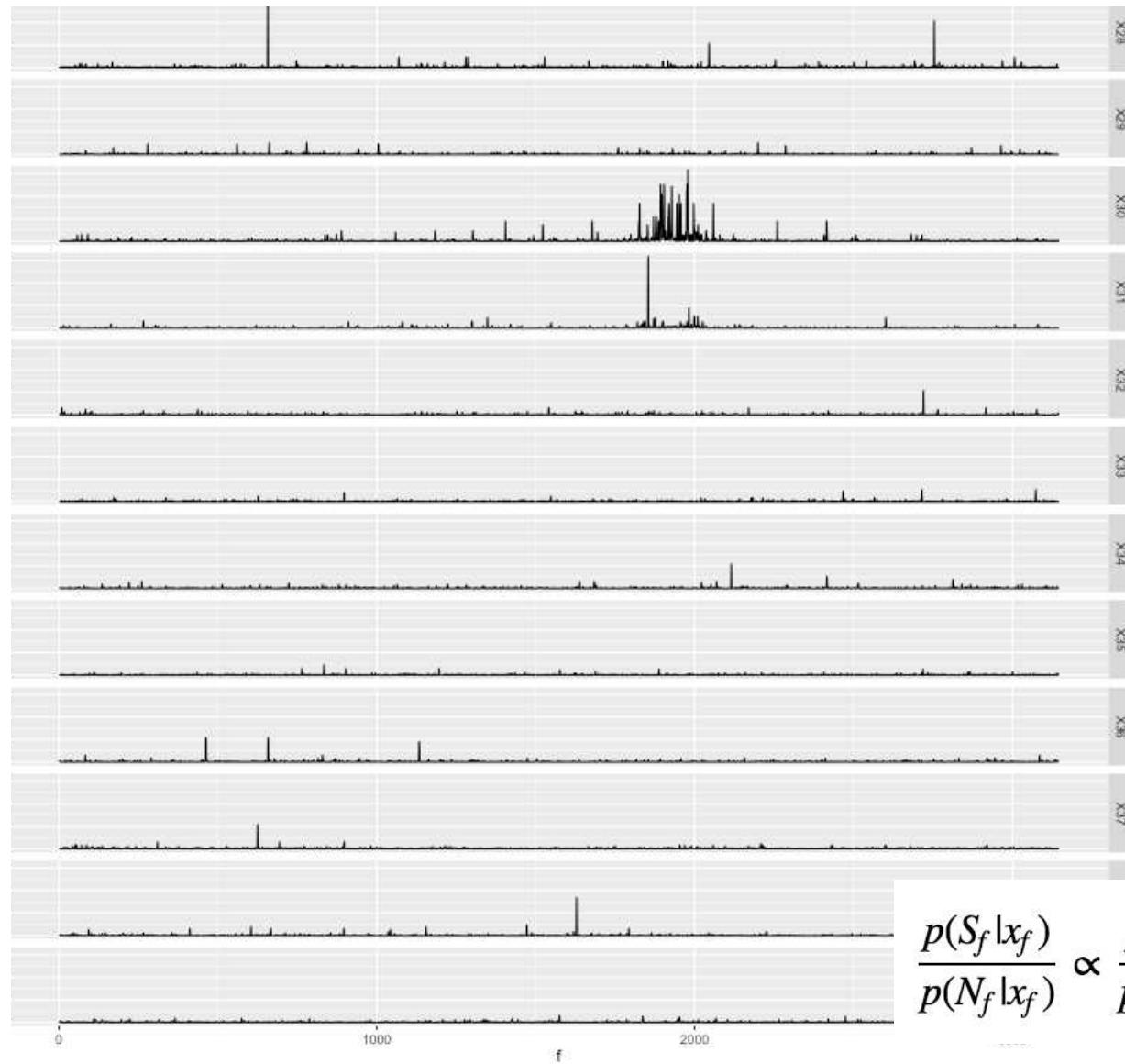
Detection?



Detection?



Detection?

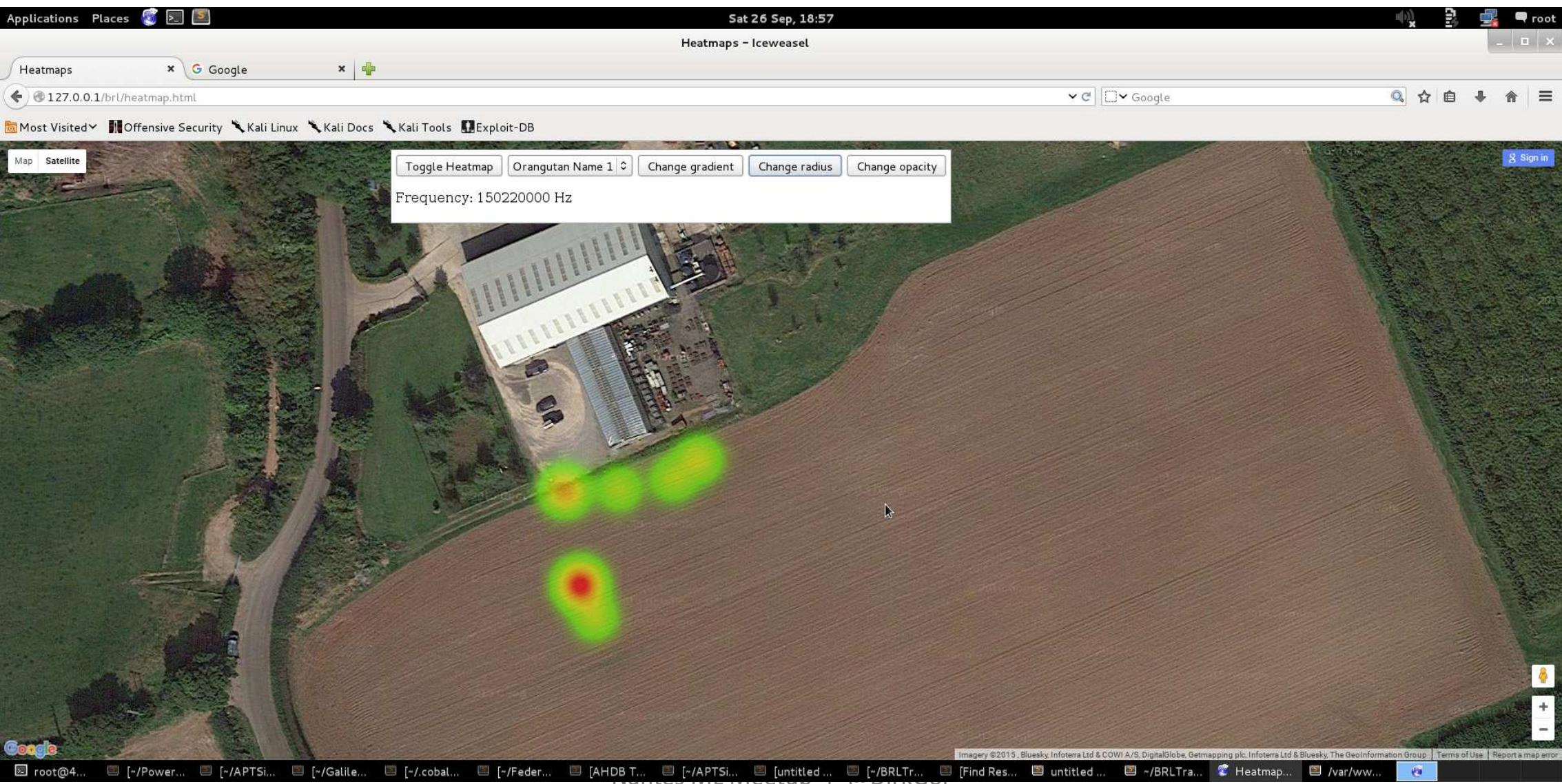


$$\frac{p(S_f | x_f)}{p(N_f | x_f)} \propto \frac{p(x_f | S_f) p(S_f)}{p(x_f | N_f) p(N_f)}$$

Proof of Principle



Proof of Principle



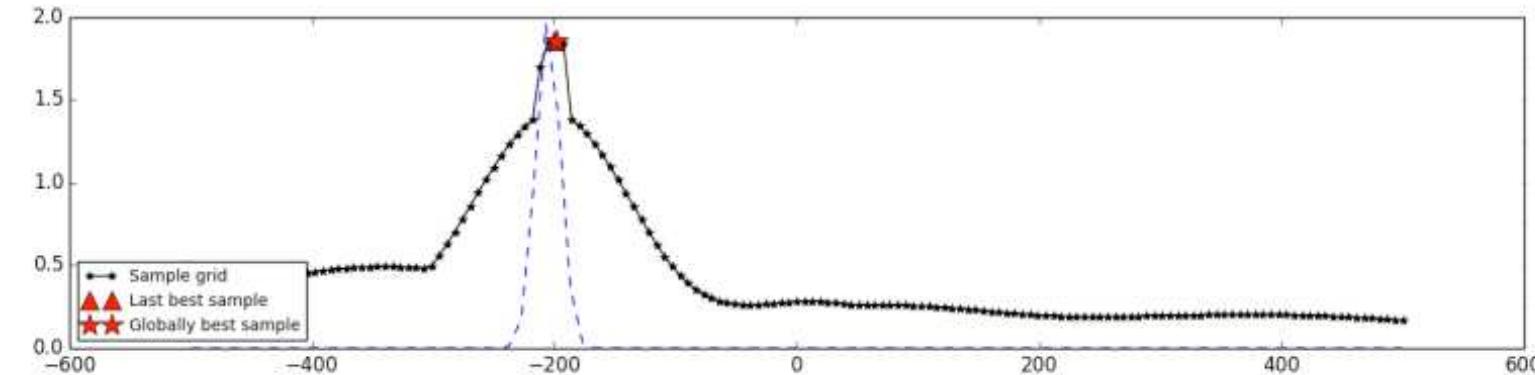
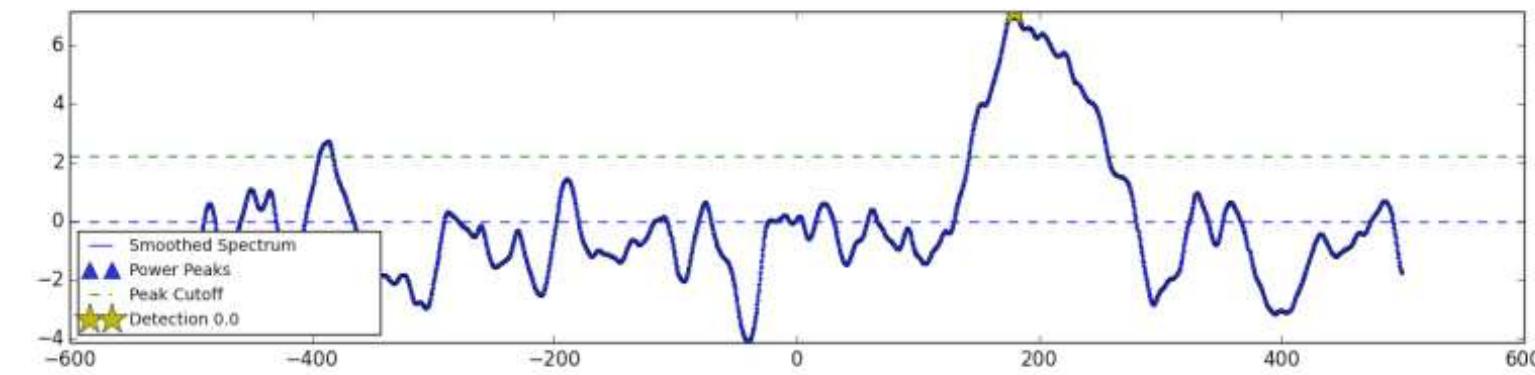
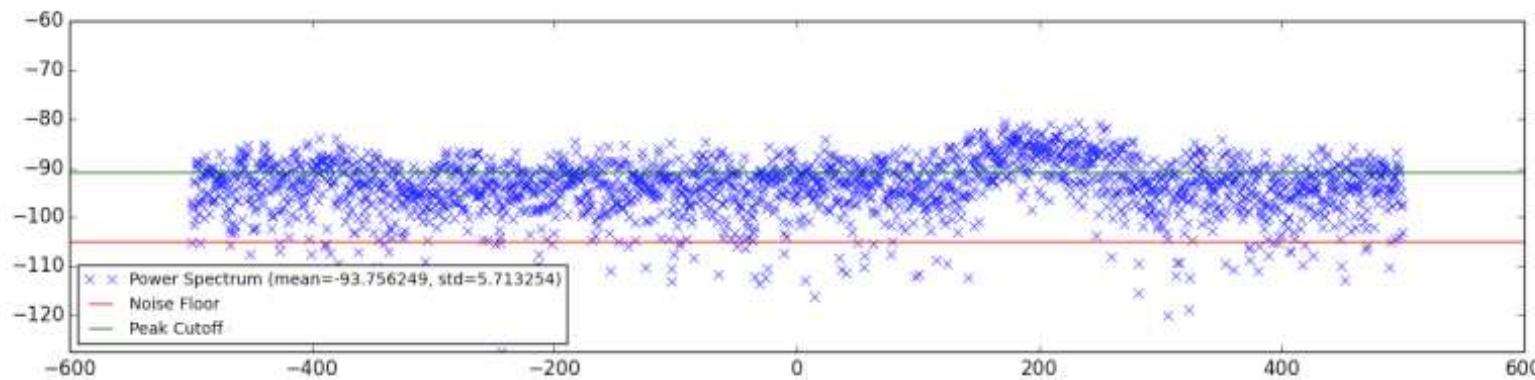
Development Tests UK



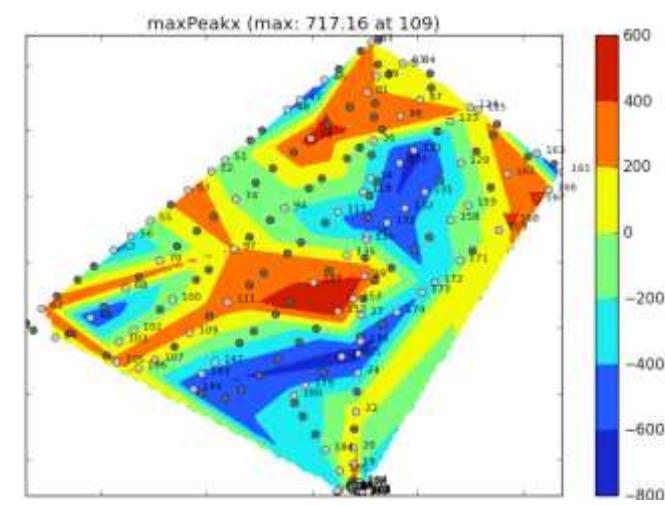
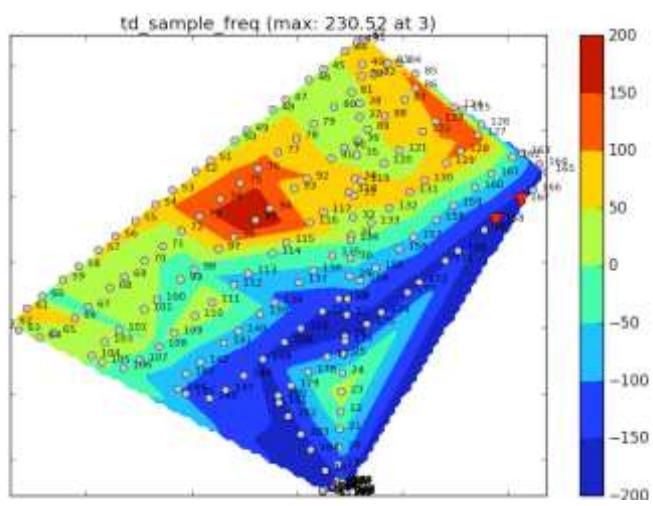
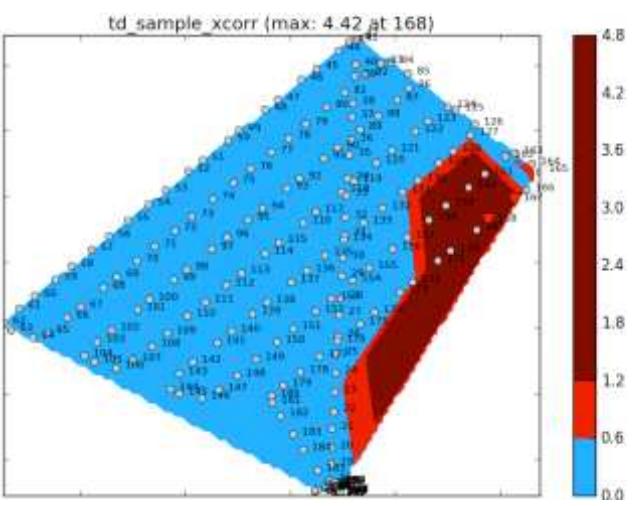
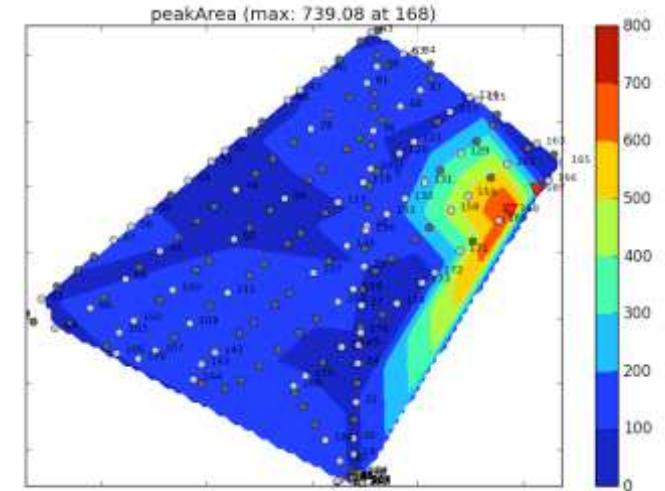
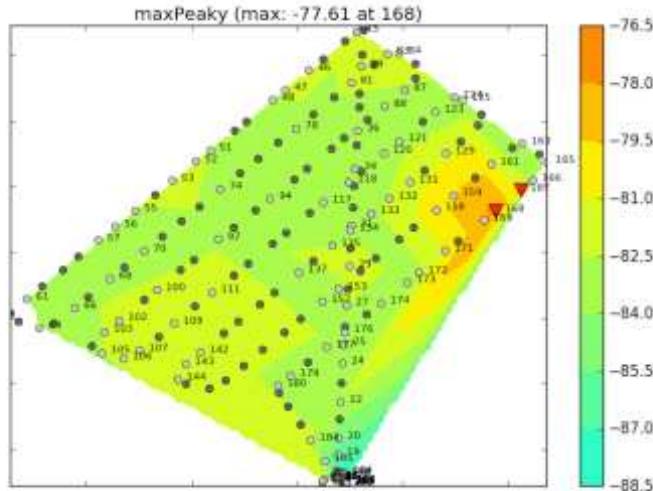
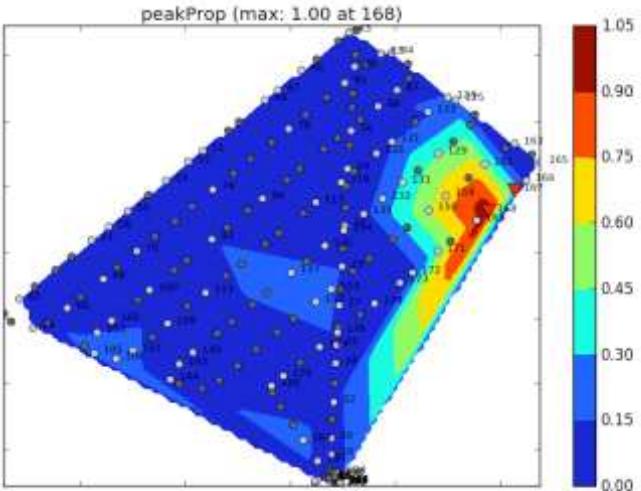
Field Tests Borneo



Detections



Detections



▶ Start tracking

Run Name ...

Drone Debug Plot

Number of Processors

Target Bandwidth

PPM

Noise Floor

SDR Gain



+ Add animal

Susi
150.38


Data (203)
Images (36)
Log

Copy
CSV

Search:

get ↑	roll ↓	td_best_xcorr ↓	battery_level ↑	vdop ↓	hdop ↑	td_best_freq ↓	td_sample_xcorr ↓	lat
0.0101307128	0.6823331362	99	65535	82	-413.4615384615	0.6889466638	-1.73	
0.0097984429	0.6823331362	99	65535	74	-413.4615384615	0.2415868751	-1.73	
0.0102064498	0.6823331362	99	65535	74	-413.4615384615	0.2480033954	-1.73	
0.009441305	0.6823331362	99	65535	74	-413.4615384615	0.3079369648	-1.73	
0.009469578	0.6823331362	99	65535	74	-413.4615384615	0.2566566671	-1.73	
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-0.0051359162	0.6823331362	99	65535	69	-413.4615384615	0.400406397	-1.73	



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**My drone stuck in a tree.
It is weird that I don't feel
bad.
I kinda knew it's coming.**

Lessons

- Drone lost but concept proven
- Lessons
 - If it can break, it will
 - If you did not test that last change, it...
 - most likely will not work (in the best case)
 - or break something else (more likely)
 - Checklists!
 - Boring and tedious but go without and it will bite you
 - Robustness > efficiency

Future

- Phase 2
 - Better radio payload
 - Improved detection logic
 - New / upgraded drone configuration
- In parallel
 - Better implants
 - External attachment
 - Different species



*“Conservation is creating hope
where there is none”*

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- Leo Biddle



Mobile Autonomy

Mobile Autonomy



Rail



Autonomous cars



Space



Urban transport



Nuclear Inspection



Offroad

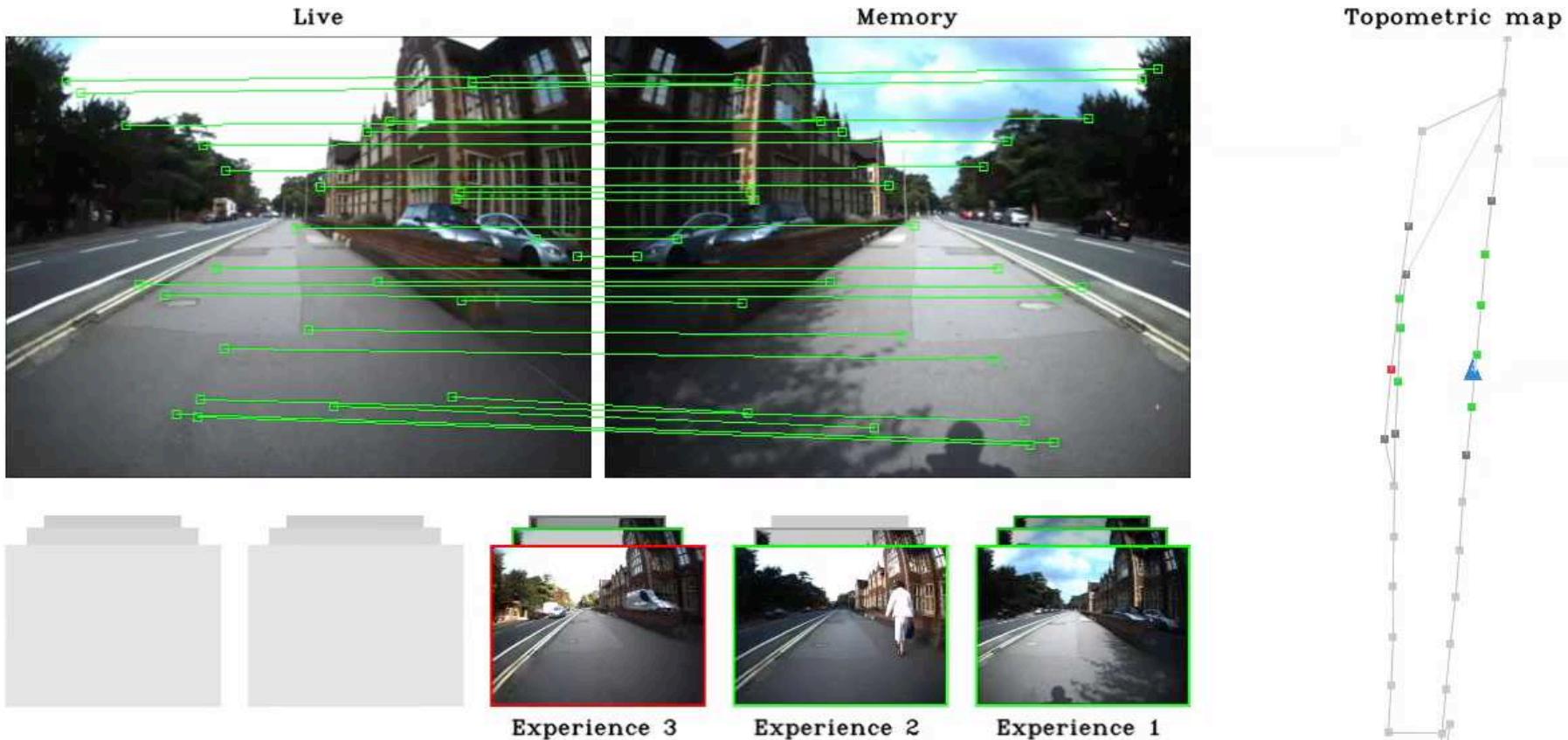
Experience-Based Navigation

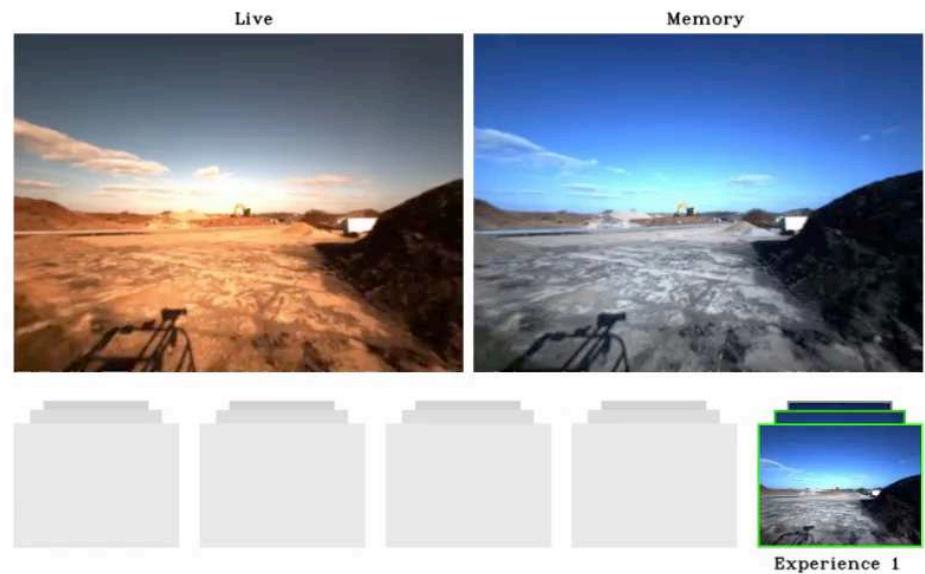
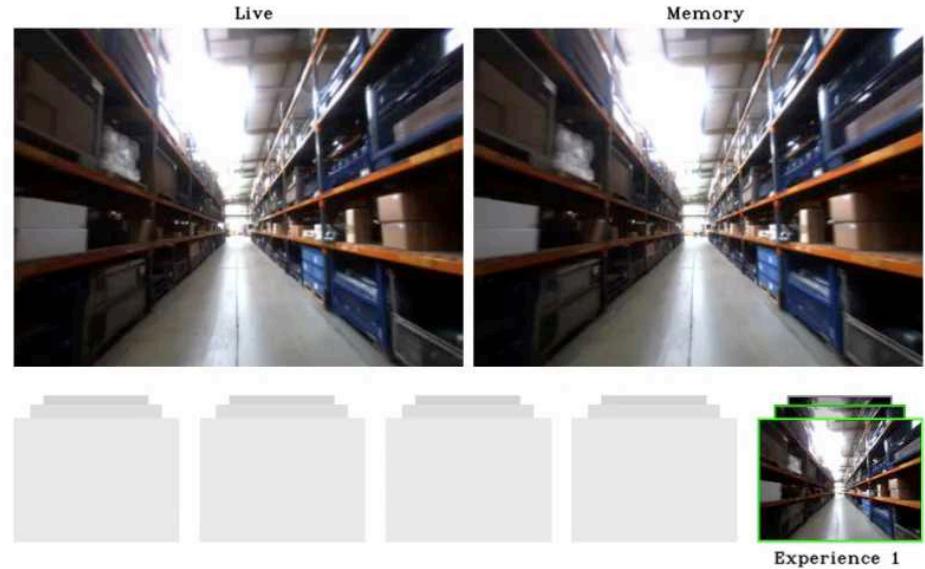
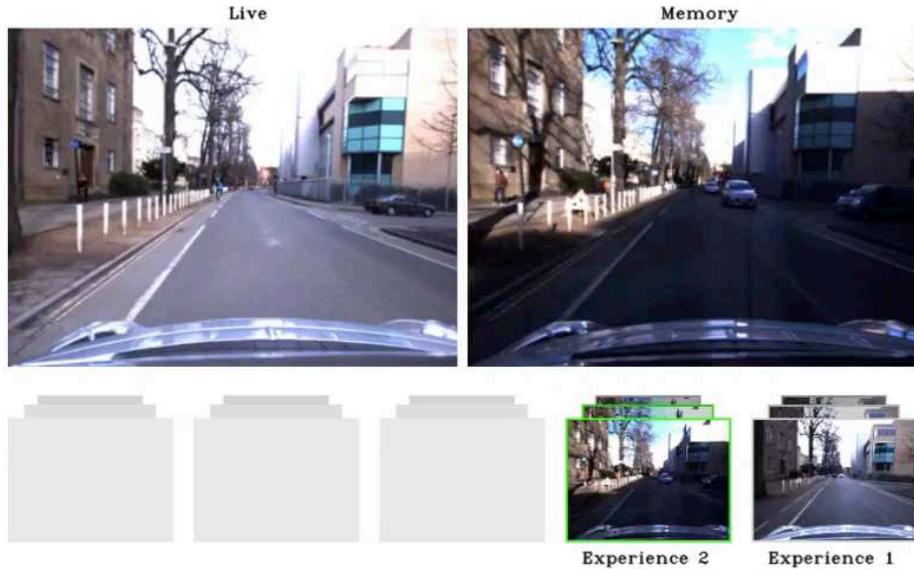


“Local excellence over global mediocracy”

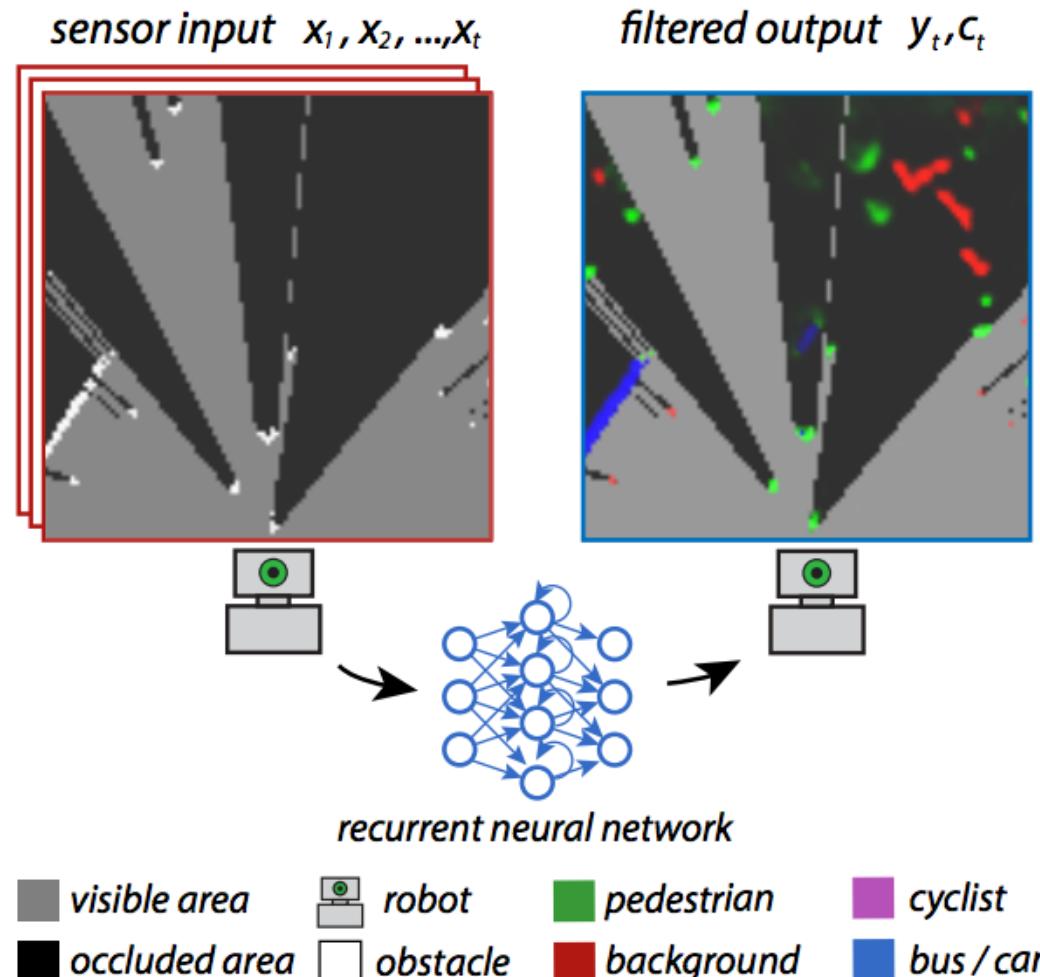
Experience Based Navigation

Experience-Based Navigation

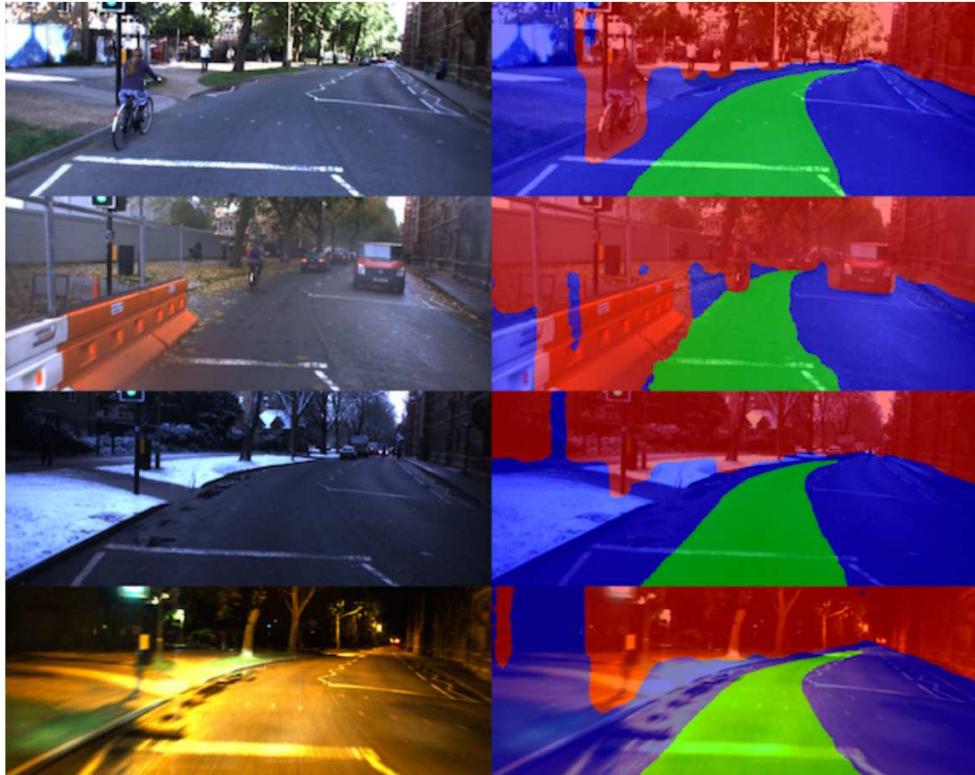




Deep Tracking



Road Segmentation



Perception

Thank you!

