"Seeing the Unseen"

Frequency Reconfigurable Ground Penetrating Radar for Landmine Detection

UCL SECReT
SECURITY SCIENCE DOCTORAL RESEARCH TRAINING CENTRE

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The Problem

- 100 million unexploded landmines scattered in 60 countries worldwide
- 26000 victims a year

- Large portions of land go unused due to fear of mines
- Major problem in agricultural based regions

- Soldiers take the first step in combating landmines
- Operations are made more difficult and dangerous due to mining of roads

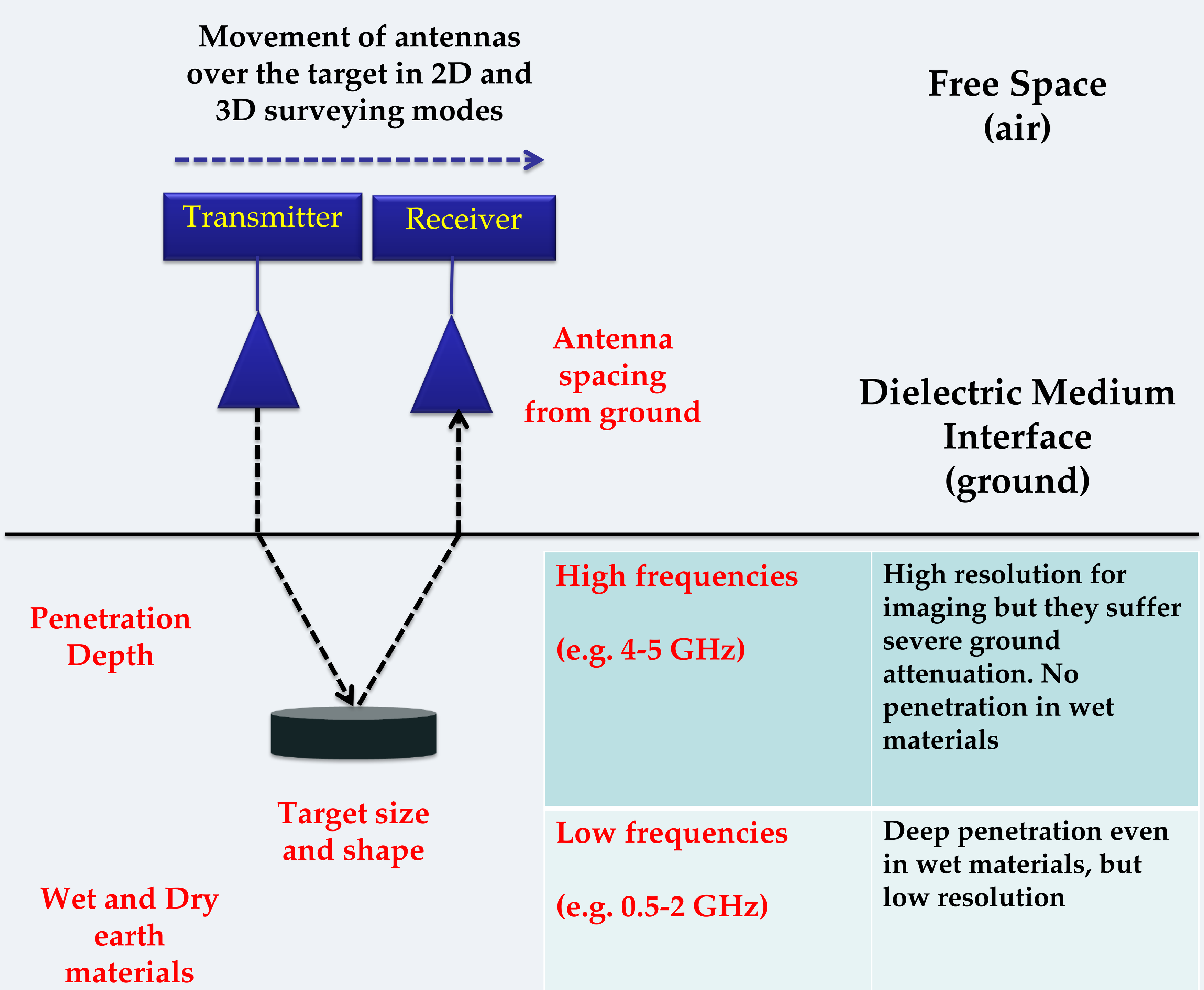
The Challenges

Modern mines can be constructed with plastics and composites, the low metal content of mines make detection extremely difficult

Different environmental conditions and terrains where landmines are randomly or strategically scattered

Surface materials and their conditions, target characteristics and buried depth limit the operational systems

Ground Penetrating Radar Principles



High frequencies (e.g. 4-5 GHz)	High resolution for imaging but they suffer severe ground attenuation. No penetration in wet materials
Low frequencies (e.g. 0.5-2 GHz)	Deep penetration even in wet materials, but low resolution

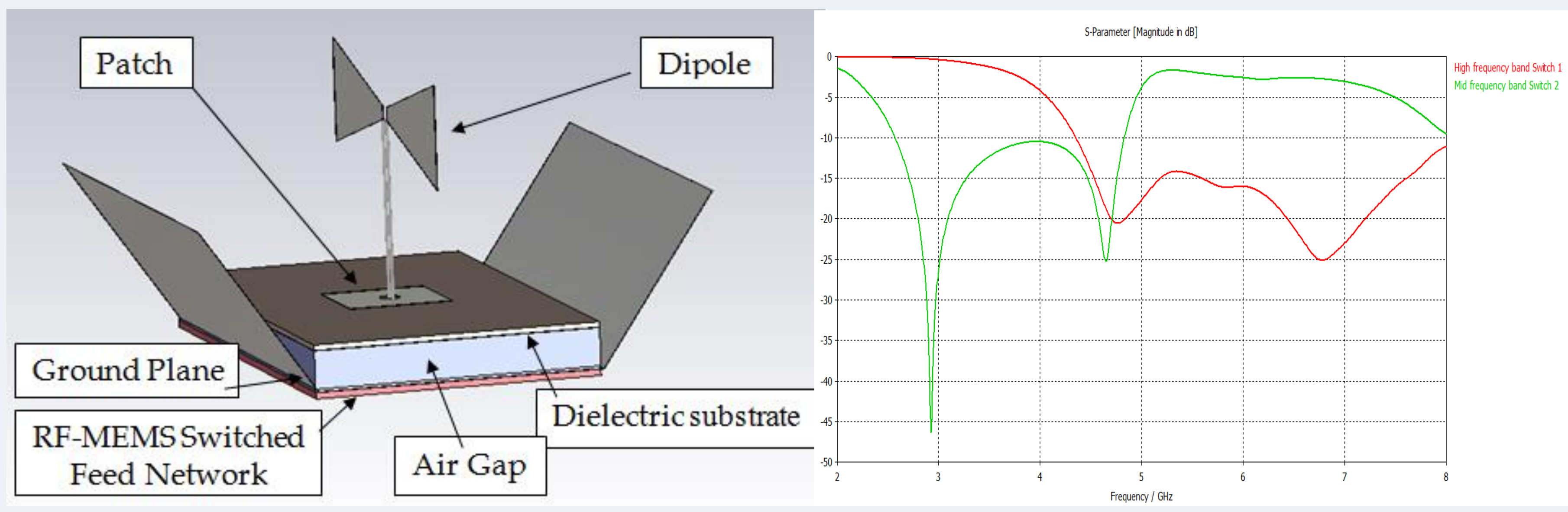
Optimum Operating Frequencies

The Radar Cross Section (RCS) of an object is dependant on a few factors such as size, material, shape, operating frequency and surface smoothness. Following frequencies are found to provide better performance for different earth materials and two type of landmines.

Optimum frequency of operation	RCS (m^2)	Material	Optimum frequency of operation	RCS (m^2)	Target
3 GHz	0.6	Dry sandy soil	0.5 GHz	2.3	AV Landmine
Below 2GHz	0.9	Wet sandy soil	3.5 GHz	1.9	AV Landmine
0.5 or 6 GHz	0.6	Concrete	6.5 GHz	4.5	AP Landmine

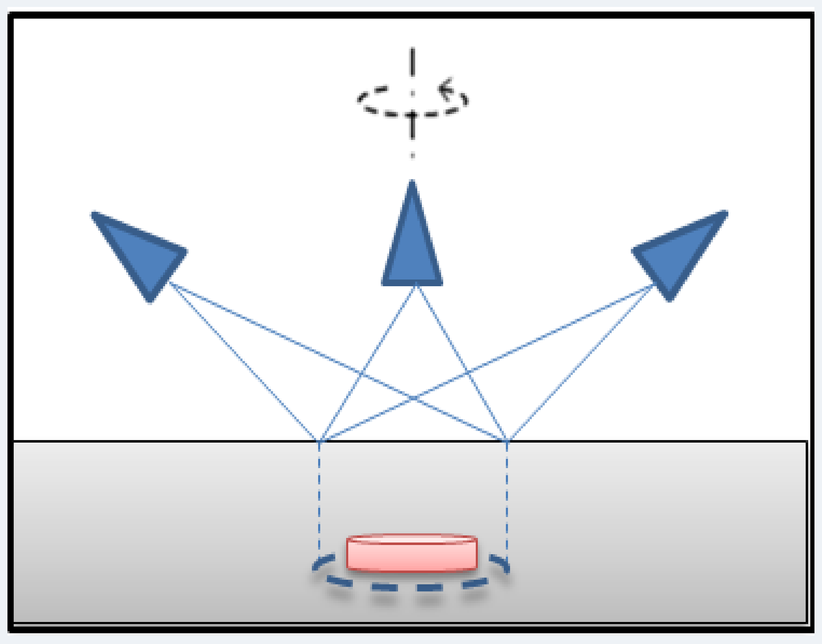
Frequency Reconfigurable Antenna Design

Conventional Ultra-Wideband (UWB) antennas are heavy size, large profile and expensive. Alternative solution lies in next generation of antennas that can reconfigure themselves in frequency in discrete or continues tuning. Not only this allows size reduction but also reduces the antenna noise. Below is an example of a design where two frequency bands of 5-8 GHz and 2-5 GHz can be reconfigured from a MEMS switched feed network.



Antenna Geometry and its simulated performance over a range of frequencies

3D Antenna Array



Substrate material (ε_r)	Rogers RT5870 (2.33)
Thickness of substrate	0.787 mm
Air gap thickness	6 mm
Diameter of feeding patch	2 mm
Diameter of radiating patch	19 mm
Separation between patches	0.787 mm
Feeding points (x, y)	(-4.8,0) , (4.8,0)
Antenna dimensions	71 mm (Length), 43 mm (Width), 60 mm (Height)

Circular motion of lightweight and compact antenna elements for 3D imaging techniques can improve the performance of GPR systems. This technique can be deployed from a rotary UAV platform surveying on top of the target.

Conclusion

A new type of antenna is introduced for Ground Penetrating Radar applications . It is lightweight, compact and small in size, having adequate characteristics for downward looking GPR systems. The antenna implementation and measurements are currently under progress.

Publications

- Amin Amiri, Kin Fai Tong, Kevin Chetty, "Reconfigurable Multiband Patch Antenna for Ground Penetrating Radar Applications", *International Conference on Electromagnetics in Advanced Applications, IEEE APCW*, South Africa, September 2012
- Amin Amiri, Kin Fai Tong, Kevin Chetty, "Feasibility study of multi-frequency Ground Penetrating Radar for rotary UAV platforms", *IET Radar, International conference on radar systems*, Scotland, October 2012
- Amin Amiri, Kin Fai Tong "Frequency Reconfigurable Patch Antenna for Landmine Detection", *International Workshop on Antenna Technology*, Germany, March 2013

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