

Contents

Preface	1
List of publications	11
Chapter 1. Introduction	1-1
Chapter 2. Ground Penetrating Radar.....	2-1
2.1. Brief historical overview	2-1
2.2. GPR principles.....	2-2
2.2.1. General	2-2
2.2.2. Different types of GPR systems	2-7
2.2.3. Propagation in lossy dielectric material	2-12
2.2.4. Impulse GPR design parameters	2-22
2.3. GPR in demining applications	2-35
2.3.1. State of the art.....	2-35
2.3.2. Field trials and conclusions	2-37
2.4. Summary.....	2-41
Chapter 3. Development of UWB GPR antennas	3-1
3.1. Introduction.....	3-1
3.2. Overview of existing GPR antennas.....	3-2
3.2.1. Conventional antennas.....	3-2
3.2.2. Non-dispersive Ultra-wideband antennas.....	3-6
3.3. GPR antenna design goals for the demining application.....	3-8
3.4. Air-filled TEM horn.....	3-9

3.4.1. TEM horn antennas	3-9
3.4.2. Study of the wire Model.....	3-14
3.4.3. Design of air-filled TEM horn.....	3-25
3.5. Dielectric-filled TEM horn	3-29
3.5.1. Influence of the filling	3-29
3.5.2. Design of the dielectric-filled TEM horn.....	3-32
3.5.3. Results of the dielectric-filled TEM horn.....	3-35
3.6. Summary.....	3-37

Chapter 4. Time domain characterisation of antennas by normalised impulse response..... 4-1

4.1. Introduction.....	4-1
4.2. Definitions of terms	4-2
4.2.1. Impulse response and frequency response function.....	4-2
4.2.2. Virtual source of a time domain antenna	4-3
4.2.3. The far field for time domain antennas	4-4
4.2.4. Electrical boresight.....	4-5
4.2.5. Definition of patterns for time domain antennas	4-6
4.3. Time domain antenna equations	4-7
4.3.1. Transmitting antenna	4-8
4.3.2. Receiving antenna.....	4-10
4.3.3. Reciprocity of time domain antennas	4-11
4.4. Normalised impulse response	4-12
4.4.1. Normalisation of the IR	4-12
4.4.2. Measurement of Normalised IR on boresight.....	4-14
4.4.3. Normalised IR off-boresight.....	4-17
4.4.4. Relation between gain and normalised IR.....	4-20
4.5. Results on TEM horns	4-21
4.6. Time domain simulations	4-24
4.7. Summary.....	4-28

Chapter 5. Modelling of the GPR radar range equation in the time domain.....	5-1
5.1. Introduction.....	5-1
5.2. Radar range equation.....	5-2
5.3. GPR range equation.....	5-3
5.4. Radar range equation in the time domain.....	5-5
5.5. GPR range equation in the time domain.....	5-9
5.6. Calculation of the different terms in the time domain GPR range equation.....	5-10
5.6.1. Transmission coefficients on the air-ground interface	5-10
5.6.2. Total path length in the air and in the ground.....	5-13
5.6.3. Ground as a low-pass filter.....	5-15
5.6.4. Impulse Response of objects	5-18
5.7. Summary.....	5-27
Chapter 6. Study of the UWB GPR.....	6-1
6.1. Introduction.....	6-1
6.2. General description of the system.....	6-1
6.3. Study of the antenna configuration.....	6-8
6.3.1. Height above the ground.....	6-8
6.3.2. Antenna Coupling.....	6-10
6.3.3. The 3 dB footprint of the antennas	6-12
6.3.4. Optimisation of the antenna off-set angle	6-13
6.4. Study of the range performance.....	6-17
6.5. Experimental results	6-23
6.5.1. Acquisition software.....	6-23
6.5.2. Results	6-24
6.6. Summary.....	6-26
Chapter 7. UWB Signal processing	7-1
7.1. Introduction.....	7-1
7.2. A-scans processing	7-3
7.2.1. Overview of A-scan processing.....	7-3

7.2.2. UWB signal processing on A-scans	7-10
7.3. Migration	7-15
7.3.1. General	7-15
7.3.2. Exploding source model	7-17
7.3.3. Overview of existing migration methods	7-19
7.4. Migration by deconvolution.....	7-25
7.4.1. Development of the method	7-26
7.4.2. Implementation of the migration method	7-30
7.4.3. Discussion.....	7-32
7.4.4. Results of the migration method.....	7-39
7.5. Summary.....	7-50
Chapter 8. Conclusions and future work	8-1
8.1. Conclusions.....	8-1
8.1.1. UWB antennas.....	8-2
8.1.2. Time domain modelling of the GPR.....	8-3
8.1.3. Migration.....	8-5
8.2. Conclusions on the use of a UWB GPR as a mine detector	8-5
8.3. Future work.....	8-6
Appendix A. Measurement of short pulse response and frequency response function of non-canonical 3D objects	A-1
A.1. Measurement set-up	A-1
A.2. Measurement of the FRF of 3D objects by dual channel analysis.....	A-2
A.3. Measurement results on Teflon cylinders and AP mines in free space	A-5
A.4. Discussion.....	A-8
Appendix B. Kirchhoff and Stolt migration.....	B-1
B.1. Kirchhoff migration	B-1
B.2. Stolt migration.....	B-5