

# The Modelling and Simulation of Passive Bistatic Radar

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# Contents

Abstract .....	iii
Statement of Originality .....	v
Acknowledgements .....	vii
List of Figures .....	ix
List of Tables .....	xiii
List of Abbreviations .....	xv
1 Introduction .....	1
1.1 Overview of Passive Radar .....	1
1.2 A Brief History of Passive Radar .....	3
1.3 Challenges of Passive Bistatic Radar .....	5
1.3.1 The Bistatic Configuration .....	5
1.3.2 Direct Signal Interference .....	6
1.3.3 Digital Broadcast Signals .....	8
1.4 Motivation .....	9
1.5 Literature Review of Radar Modelling and Simulation .....	10
1.6 Thesis Overview .....	12
2 Basic Modelling .....	13
2.1 The Purpose of Modelling and Simulation .....	13
2.2 Overview of the Rudimentary Model .....	14
2.3 Description of the Rudimentary Model Elements .....	18
2.3.1 Target Power Unit .....	18
2.3.2 DSI Power Unit .....	18
2.3.3 Propagation Loss Unit .....	19
2.3.4 Antenna Gain Unit .....	19
2.3.5 RCS Unit .....	19
2.3.6 Signal Generation Unit .....	20
2.3.7 Autocorrelation Unit .....	20
2.3.8 ARD Display .....	20
2.4 Discussion of the Rudimentary Model .....	21
2.5 Verification of the Rudimentary Model: An Example Application ..	21
2.6 Simulation of Amplitude Range-Doppler (ARD) Displays .....	26
2.6.1 Modelling of Target Doppler .....	26
2.6.2 Testing of ARD Display Generator .....	29
2.7 Discussion .....	34
3 Advanced Propagation .....	36
3.1 Propagation Loss Unit .....	36
3.2 Terrain Map Generator .....	37
3.3 Diffraction Loss Unit .....	39
3.3.1 Motivation .....	39
3.3.2 Background Theory .....	40
3.3.3 Operation .....	42
3.3.4 Verification .....	43
3.4 Multipath Loss Unit .....	45
3.4.1 Background Theory .....	45
3.4.2 Operation .....	45
3.4.3 Verification .....	46
3.5 Depolarisation Loss Unit .....	47
3.5.1 Background Theory .....	47
3.5.2 Operation .....	49
3.6 Effect of refinements on DSI .....	49

4	Radar Cross-section Modelling .....	52
4.1	Explanation of the Problem .....	52
4.2	Target RCS Modelling.....	53
4.2.1	Modelling of Small Executive Jet .....	53
4.2.2	Simulation of RCS of Small Executive Jet.....	55
4.3	Antenna Gain Modelling .....	65
4.3.1	Transmitter Gain Pattern .....	65
4.3.2	Receiver Gain Pattern.....	65
4.4	Implications for Radar Modelling.....	69
5	Some Applications of the Simulator.....	70
5.1	Simulation of Several Realistic Scenarios .....	70
5.2	Application of Modelling to DSI Mitigation .....	72
5.2.1	Investigating DSI around Bath .....	73
5.2.2	Investigating DSI around Adelaide .....	80
5.3	Discussion.....	84
6	Conclusion and Future Work.....	86
6.1	Summary .....	86
6.2	Extensions.....	86
	Appendix A – Derivation of Loss Due to a Screen .....	88
	Appendix B – RCS Matrices from NEC Simulations .....	91
	Appendix C – Matlab Code Listing.....	93
	Bibliography.....	115

## Abstract

Passive radar systems use illuminations by transmitters of opportunity, such as digital audio broadcasts (DAB), to detect and track targets. In bistatic radar systems, the transmitting and receiving antennas are separate and widely spaced. In an era of strong demand for enhanced surveillance, proponents of passive bistatic radar (PBR) technology assert that it offers many benefits, in particular the use of already existing transmitters. PBR systems suffer from high system complexity however. This presents challenges for PBR designers and researchers, as testing ideas experimentally is prohibitively expensive.

Direct signal interference (DSI) is a major problem in all passive radar systems and occurs when the direct signals transmitted by the illuminators are stronger than the target return signals. This can lead to a large reduction in the dynamic range that is available for target detection. DAB networks are particularly problematic because there are often a large number of illuminators present that are transmitting virtually identical signals at the same frequency.

This thesis describes the development of a realistic model/simulator for a general PBR system that can be used to develop radar algorithms, DSI mitigation techniques and optimise the design of radar systems. The simulator can be applied to multi-transmitter/multi-receiver systems, which allows researchers to test ideas without building equipment.

In this thesis, a brief introduction is given to PBR, including its history, challenges and an overview of radar modelling and simulation. A rudimentary PBR model is then described and verified by comparison of a simulated radar signal produced by the model with that of an off-the-air radar signal.

The rudimentary model is made more realistic by the addition of more sophisticated propagation effects, namely, diffraction, multipath and depolarisation. Further enhancements are made with the development of radar cross section and antenna gain components. The model is then used to simulate a number of realistic scenarios involving typical aircraft flight paths around the University of Bath in the UK.

Finally, the model is applied to the testing of a DSI mitigation technique, namely, shielding by topography, using the Bath region as a test case. The success of the simulation results suggests that the technique can be used in the Adelaide area of South Australia.

The simulator serves as a virtual multi-static environment for developing applications such as a tracker. A tracker would need to function in a variety of situations, and its operation would be affected by factors such as terrain and DSI. A detailed knowledge of the propagation environment would be necessary for the development of such a tracker, and the simulator can provide this knowledge.



## **Statement of Originality**

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Yik Ling Lim and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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**Date:** .....





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## List of Figures

Figure 1 - (a) Monostatic radar uses a single transmit/receive antenna (b) Bistatic radar has separate transmitting and receiving antennas that are widely spaced .....	2
Figure 2 - Bistatic geometry and typical requirements for bistatic radar operation .....	6
Figure 3 - Passive bistatic radar configuration .....	7
Figure 4 - Passive bistatic radar configuration .....	15
Figure 5 - Block diagram of simulator .....	17
Figure 6 - The geometry of the radar at Bath .....	21
Figure 7 - Autocorrelation of Synthesised Signal (3 illuminators transmitting) .....	23
Figure 8 - Autocorrelation of Off-the-Air Signal .....	24
Figure 9 - Autocorrelation of Synthesised Signal (10 illuminators transmitting) .....	25
Figure 10 - Simulated autocorrelation with just the Abergavenny transmitter on .....	26
Figure 11 - ARD display for scenario with no targets and all 10 illuminators on. The 10 DSI detections are shown circled. ....	30
Figure 12 - Diagram showing second simulation scenario (not to scale) .....	31
Figure 13 - ARD display for scenario with single target travelling north at 180 m/s and only one illuminator on, using simulated data, during first observation .....	32
Figure 14 - ARD display for scenario with single target travelling north at 180 m/s and only one illuminator on, using simulated data, 17 seconds after first observation .....	33
Figure 15 - ARD display for scenario with single target travelling north at 180 m/s and only one illuminator on, using simulated data, 31 seconds after second observation .....	34
Figure 16 - Propagation Loss Unit block diagram .....	36
Figure 17 - Terrain Map Generator block diagram .....	37
Figure 18 - Buildings in the vicinity of the receiver (shown circled) .....	39
Figure 19 - Propagation obscured by a screen .....	40
Figure 20 - Propagation over hilly ground .....	42
Figure 21 - Diffraction Loss Unit block diagram .....	43
Figure 22 - Geometry for infinite-width plateau model .....	44
Figure 23 - Numerical and experimental results for the normalised attenuation function against plateau height for total and individual component fields [57]. The Diffraction Loss Unit test is concerned only with the experimental results for the non-interacting field (marked as $\Delta$ ) .....	44
Figure 24 - Plot of attenuation against plateau height for the non-interacting field obtained during testing of Diffraction Loss Unit .....	45
Figure 25 - Multipath Loss Unit block diagram .....	46
Figure 26 - Test scenario for Multipath Loss Unit verification .....	47
Figure 27 - Autocorrelation of Synthesised Signal .....	50
Figure 28 - Autocorrelation of Off-the-Air Signal .....	51
Figure 29 - Mesh for small executive jet .....	54
Figure 30 - Diagram showing target relative to transmitter and receiver .....	55

Figure 31 - Radar cross section pattern for nose-on illumination ( $\phi = 0$ degrees) in vertical polarisation, relative to coordinate axes (not to scale).....	56
Figure 32 - Radar cross section pattern for side-on illumination ( $\phi = 90$ degrees) in vertical polarisation, relative to coordinate axes (not to scale).....	57
Figure 33 - Radar cross section pattern for nose-on illumination ( $\phi = 0$ degrees) in vertical polarisation.....	58
Figure 34 - Radar cross section pattern for side-on illumination ( $\phi = 90$ degrees) in vertical polarisation.....	59
Figure 35 - Radar cross section pattern for tail-on illumination ( $\phi = 180$ degrees) in vertical polarisation.....	60
Figure 36 - Radar cross section pattern for 45-degree illumination in vertical polarisation.....	61
Figure 37 - Radar cross section pattern for nose-on illumination ( $\phi = 0$ degrees) in horizontal polarisation.....	62
Figure 38 - Radar cross section pattern for side-on illumination ( $\phi = 90$ degrees) in horizontal polarisation.....	63
Figure 39 - Radar cross section pattern for tail-on illumination ( $\phi = 180$ degrees) in horizontal polarisation.....	63
Figure 40 - Radar cross section pattern for 45-degree illumination in horizontal polarisation.....	64
Figure 41 - Geometry of Yagi-Uda antenna.....	66
Figure 42 - Far-field gain pattern of Yagi-Uda antenna.....	66
Figure 43 - Geometry of target-pointing array.....	67
Figure 44 - Far-field gain pattern of receiver array pointing towards area of expected targets.....	68
Figure 45 - Accumulated observations of aircraft crossing boresight in prior research project.....	70
Figure 46 - Simulated observations of aircraft crossing boresight.....	71
Figure 47 - Simulated observations of aircraft circling Bristol Airport.....	72
Figure 48 - The terrain map for the Bath region.....	73
Figure 49 - Map of illumination from Bath, at a height of 201 m above sea level.....	74
Figure 50 - Map of illumination from Mendip, at a height of 201 m above sea level.....	75
Figure 51 - Map showing illumination from Mendip at a height of about 201 m above sea level calculated by a PE simulator [66].....	75
Figure 52 - Map of illumination from Naish Hill, at a height of 201 m above sea level.....	75
Figure 53 - Map of illumination from Wenvoe, at a height of 201 m above sea level.....	76
Figure 54 - Map of illumination from Wenvoe at a height of 250 m above sea level.....	77
Figure 55 - Map of illumination from Wenvoe at a height of 300 m above sea level.....	77
Figure 56 - Map of total DSI power across region centred on the University of Bath at ( $51.378944^{\circ}\text{N}$ , $2.327967^{\circ}\text{W}$ ).....	78
Figure 57 - Map of target visibility around low DSI site at ( $51.356^{\circ}\text{N}$ , $2.31^{\circ}\text{W}$ ).....	79
Figure 58 - Map of target visibility around low DSI site at ( $51.356^{\circ}\text{N}$ , $2.31^{\circ}\text{W}$ ) with receiver 30 m above ground.....	79
Figure 59 - Map of target visibility around low DSI site at ( $51.356^{\circ}\text{N}$ , $2.31^{\circ}\text{W}$ ) with receiver 40 m above ground.....	80

Figure 60 - Terrain map for the Adelaide region .....	81
Figure 61 - First map showing maximum DSI around Mt Lofty illuminator at (34.9825°S, 138.706667°E) .....	82
Figure 62 - Map of target visibility around low DSI site at (35.07°S, 138.85°E) .....	83
Figure 63 - Second map of maximum DSI around Mt Lofty illuminator .....	83
Figure 64 - Map of target visibility around low DSI site at (35.5°S, 138.5°E)	84



## List of Tables

Table 1 - Results of simulating autocorrelations with single illuminators on.. 26





## List of Abbreviations

ADC	Analog-to-digital converter
AOA	Angle of arrival
ARD	Amplitude range-Doppler
CBD	Central business district
CFAR	Constant false alarm rate
COFDM	Coded orthogonal frequency division multiplexing
CW	Continuous wave
DAB	Digital audio broadcast
DR	Dynamic range
DSI	Direct signal interference
DTED	Detailed terrain elevation data
DTV-T	Digital television – terrestrial
DVB	Digital video broadcast
FM	Frequency modulation
GPS	Global positioning system
GSM	Global system for mobile
LOS	Line-of-sight
NEC	Numerical electromagnetics code
PBR	Passive bistatic radar
PE	Parabolic equation
RC	Radar channel
RCS	Radar cross section
SIR	Signal to interference ratio
UHF	Ultra high frequency
UK	United Kingdom
VHF	Very high frequency