Contents

Preface ix

Introduction xiii

Chapter 1 Modern Approaches to Modern Radar Problems 1
- 1.1 Target Detection Methods, Old and New 1
- 1.2 Discriminating Man-Made Targets From Clutter 4
- 1.3 Target Identification 7
  - 1.3.1 Scope of the Treatment 9
- 1.4 Summary of Conventional Radar Imaging 9
- 1.5 Radar Imaging Terminology 11

References 15

Chapter 2 The Backscattering Behavior of Man-Made Targets 17
- 2.1 The Applicability of the Point-Target Resolution Theory 17
- 2.2 General Scatterer Classes and Their Significance 20
  - 2.2.1 Discontinuities 20
  - 2.2.2 Smooth Extended Surfaces 21
  - 2.2.3 Corners 22
  - 2.2.4 Regular Cavities 23
  - 2.2.5 Irregular Cavities 24
  - 2.2.6 Multiple-Bounce Responses 24
  - 2.2.7 Traveling Wave Returns 25
  - 2.2.8 Multiple Backscattering Modes 25
- 2.3 The Problem of Target Modeling 26
  - 2.3.1 Nondispersive and Dispersive Scatterers 26
  - 2.3.2 The Significance of Dispersive and Nondispersive Scatterers 27
  - 2.3.3 Target Modeling and Scatterer Prediction 28

2.4 Sideband Responses 29
2.4.1 General Nature of Sideband Responses 29
2.4.2 An Illustration of Sideband Responses in a Ground Vehicle Image 30
2.4.3 Properties of the Sideband Responses 34
2.4.4 Illustrations of Sideband Responses 45
2.5 Summary 65
References 68

Chapter 3 The Resolution Problem 71
3.1 Resolution and Measurement Precision 71
3.2 Resolution Performance 77
3.3 Radar Signals and Resolution 82
3.3.1 Unmodulated Short Pulse 82
3.3.2 Linear FM Signal 82
3.3.3 Phase Shift Code 84
3.4 Summary 84
References 86

Chapter 4 Measurement Principles for Point Reflectors 87
4.1 The Single Point Scatterer 87
4.1.1 Mathematics as a Foundation for Modern Radar Signal Processing 87
4.1.2 Signal Domain and Image Domain 91
4.1.3 Radar Return From a Fixed Point Scatterer 93
4.1.4 Fixed Point Scatterer in a Noise Background 101
4.1.5 Fixed Point Scatterer in Noise, Low SNR per Pulse 108
4.1.6 Detection of a Fixed Point Target in Noise 116
4.1.7 Measurements in the Range Domain 123
4.2 Multiple Fixed Point Scatterers with Constant Dopplers 124
4.2.1 General Approach to the Analysis 124
4.2.2 Image Domain Analysis Versus Transform Domain Analysis 128
4.2.3 Amplitude and Phase Patterns of Two Fixed Point Scatterers 132
4.2.4 Resolution of Two Fixed Point Scatterers 135
4.2.5 Three and More Fixed Point Scatterers 143
4.2.6 Interpretation 148
4.3 Two Unresolved Fixed Point Scatterers 151
4.4 Curved Phase Functions From Unresolved Multiple Fixed Point Scatterers 159
4.5 Development and Automation of CIA Algorithms 163
4.6 Summary 169
References 171

Chapter 5 Specific Target Features 173
5.1 Smooth Curved Surfaces or Sliding Point Scatterers 173
5.1.1 Flat Plates 175
5.2 Multiple-Bounce Reflectors 175
5.2.1 Overview 175
5.2.2 The Trihedral Corner Reflector 176
5.2.3 The Dihedral Corner Reflector 187
5.3 Features With Shifting Phase Centers 191
5.3.1 General Consideration of Phase Center Shifts 193
5.3.2 The Sideband Generation Mechanism 198
5.4 Smooth Backscattering Modes From Extended Features 214
5.4.1 Nature of the Backscattering 214
5.4.2 Measurement of Feature Size 218
5.5 Features With Irregular Phase Center Motions 226
5.6 Curved Surfaces 232
5.7 Multiple Delayed Returns 237
5.7.1 Delayed Returns for Aircraft 237
5.7.2 Delayed Returns for Ground Vehicles 241
5.8 Features With Traveling Wave Responses 251
5.9 Ground-Bounce Returns 266
5.9.1 Nature of Ground-Bounce Responses 266
5.9.2 Ground-Bounce Illumination of Single Features 267
5.9.3 Parallel-Plate Bounces 268
5.9.4 Repetitive Bounces Between Features, Induced by Ground Bounces 272
5.9.5 Noncoherency via Ground Bounce 275
5.10 Summary 279
References 282

Chapter 6 Motion Compensation for Moving Targets 283
6.1 Terminology and Scope of the Treatment 283
6.2 Requirements on the Motion Compensation 284
6.3 Motion Compensation Steps 286
6.3.1 General Description of the Motion Compensation 286
6.3.2 Range Tracking of the Entire Aircraft 289
6.3.3 Doppler Tracking of the Entire Aircraft 292
6.3.4 The Necessity of Tracking Individual Scatterers 303
6.3.5 Doppler Tracking of Individual Scatterers 311
6.3.6 Phase Tracking of a Reference Scatterer 312
6.3.7 Correction of the Nonuniform Rotation Rate 321
6.3.8 Polar Format Processing 325
6.3.9 Fine Phase Compensation 326
6.4 Summary 329
Reference 331

Chapter 7 Generation of the Target Outlines 339
7.1 Measurement Procedure 339
7.2 Basic Measurement Principles 341
7.3 Example of Outline Generation for a Ground Vehicle 346
7.4 Example of a Case With Very Weak Edge Scatterers 381
7.5 Summary 399

Chapter 8 The Significance and Problems of Crossrange Resolution 405
8.1 Resolution Versus Measurement Precision 405
8.2 Measurements on Images With Different Degrees of Crossrange Resolution 407
8.3 Imaging at Broadside Aspects 432
8.4 Summary 442

Chapter 9 Special Processing Algorithms 449
9.1 Algorithms for Scatterer Resolution 449
9.1.1 The Two-Scatterer Algorithm (TSA) 449
9.1.2 Superresolution With the TSA 460
9.1.3 Setting the Boundaries of the Transform Window 466
9.1.4 Two-Dimensional Use of the TSA 469
9.1.5 The Enhanced Resolution Algorithm 475
9.2 Discrimination Algorithms for Responses From Man-Made Targets 481
9.2.1 Target Detection and Discrimination Algorithms 481
9.2.2 Algorithms for Two-Dimensional Resolution 484
9.2.3 Algorithms for One-Dimensional Resolution in Range 494
9.3 Summary 499

Chapter 10 Concluding Remarks 501

Appendix The Two-Scatterer Algorithm 505

About the Authors 517

Index 519