



**FIXED  
BROADBAND  
WIRELESS  
SYSTEM DESIGN**

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HARRY R. ANDERSON

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WIRELESS  
SYSTEM DESIGN**



# **FIXED BROADBAND WIRELESS SYSTEM DESIGN**

HARRY R. ANDERSON, Ph.D., P.E.

CONSULTING ENGINEER  
USA



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# Contents

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<b>Preface</b>	<b>xvii</b>
<b>1 Fixed Broadband Wireless Systems</b>	<b>1</b>
1.1 Introduction	1
1.2 Evolution of Wireless Systems	2
1.3 Models for Wireless System Design	4
1.4 Demand for Communication Services	7
1.5 Licensed Frequency Bands	8
1.6 License-Exempt Bands	10
1.7 Technical Standards	12
1.7.1 IEEE 802.11 Standards	13
1.7.2 IEEE 802.16 Standards	14
1.7.3 ETSI BRAN Standards	14
1.8 Fixed, Portable, and Mobile Terminals	15
1.9 Types of Fixed Wireless Networks	17
1.9.1 Point-to-Point (PTP) Networks	17
1.9.2 Consecutive Point and Mesh Networks	17
1.9.3 Point-to-Multipoint (PMP) Networks	18
1.9.4 NLOS Point-to-Multipoint Networks	19
1.10 Organization of this Book	20
1.11 Future Directions in Fixed Broadband Wireless	22
1.12 Conclusions	23
1.13 References	23
<b>2 Electromagnetic Wave Propagation</b>	<b>25</b>
2.1 Introduction	25
2.2 Maxwell's Equations and Wave Equations	25
2.3 Plane and Spherical Waves	27
2.3.1 Impedance of Free Space and Other Transmission Media	28
2.3.2 Power in a Plane Wave	29
2.3.3 Spherical Waves	29
2.4 Linear, Circular, Elliptical, and Orthogonal Polarizations	30
2.5 Free-Space Propagation	31
2.5.1 Path Attenuation between Two Antennas	31
2.5.2 Field Strength at a Distance	32

2.6	Reflection	33
2.6.1	Specular Reflection	33
2.6.2	Physical Optics	35
2.6.3	Reflections from Rough Surfaces	37
2.7	Diffraction	40
2.7.1	Wedge Diffraction	40
2.7.2	Knife-Edge Diffraction	45
2.8	Fresnel Zones and Path Clearance	51
2.9	Material Transmission	53
2.9.1	Transmission into Structures	54
2.9.2	Transmission through Foliage	54
2.10	Atmospheric Refraction	56
2.10.1	Statistics of Varying Refractivity Gradients	59
2.10.2	Sub-Refraction	61
2.10.3	Super-Refraction and Ducting	61
2.11	Atmospheric Absorption	62
2.12	Rain Attenuation and Depolarization	62
2.13	Free-Space Optics (FSO) Propagation	65
2.13.1	Beam Divergence	66
2.13.2	Fog, Snow, and Rain Attenuation	67
2.13.3	Atmospheric Scintillation	67
2.14	Conclusions	68
2.15	References	68
<b>3</b>	<b>Propagation and Channel Models</b>	<b>71</b>
3.1	Introduction	71
3.1.1	Model Classifications	72
3.1.2	Fading Models	73
3.2	Theoretical, Empirical, and Physical Models	73
3.2.1	Theoretical Channel Models	74
3.2.1.1	Theoretical, Non-Time-Dispersive	75
3.2.1.2	Theoretical, Time-Dispersive	75
3.2.2	Empirical Channel Models	75
3.2.2.1	Empirical, Non-Time-Dispersive	77
3.2.2.2	Empirical, Time-Dispersive	77
3.2.3	Physical Channel Models	78
3.2.3.1	Physical, Non-Time-Dispersive, Not Site-Specific	78
3.2.3.2	Physical, Non-Time-Dispersive, Site-Specific	78
3.2.3.3	Physical, Time-Dispersive, Site-Specific	79
3.3	Generic Wideband Channel Model	79
3.3.1	Wideband Channel Response	83
3.3.1.1	Time-Variant and Static Channels	85

	3.3.1.2	Tapped Delay Line Model	88
	3.3.1.3	Frequency Domain Representations	89
3.4		Empirical Models	89
	3.4.1	IEEE 802.16 (SUI) Models	90
	3.4.2	COST-231 Hata Model	93
	3.4.3	MMDS Band Empirical Path Loss	94
	3.4.4	3D Path Loss Surface Models	96
3.5		Physical Models	97
	3.5.1	Free Space + RMD	98
	3.5.1.1	Line-of-Sight Assessment	98
	3.5.1.2	LOS Path Analysis	99
	3.5.1.3	NLOS Path Analysis	102
	3.5.2	Multiple Obstacle Analysis	102
	3.5.2.1	Epstein–Peterson Method	105
	3.5.2.2	Deygout Method	106
	3.5.3	Longley–Rice Model	107
	3.5.4	TIREM Model	107
	3.5.5	Anderson 2D Model	107
	3.5.6	NLOS Dominant Ray Path Loss Model	108
	3.5.6.1	Building Clutter Loss	110
	3.5.7	Ray-Tracing	115
	3.5.8	Simplified Indoor Model	120
3.6		Conclusions	122
3.7		References	123
<b>4</b>		<b>Fading Models</b>	<b>127</b>
4.1		Introduction	127
	4.1.1	Link Performance with Fading	128
4.2		Atmospheric Fading Models	129
	4.2.1	Microwave Multipath Fading Mechanisms	130
	4.2.2	Vigants–Barnett Model	132
	4.2.3	ITU-R P.530-8 Model	134
	4.2.4	Dispersive (Frequency-Selective) Fading	137
	4.2.4.1	Coherence Bandwidth	138
	4.2.4.2	Dispersive Fade Margin	140
4.3		Rain Fading Models	143
	4.3.1	Crane Rain Fade Model	144
	4.3.2	ITU-R P.530-8 Model	146
	4.3.3	Short-Range Rain Fading	147
	4.3.4	Other Precipitation Losses	149
	4.3.5	Cross-Polarization Discrimination Fading Model	149
4.4		Correlated Rain Fading Model	151
4.5		Free Space Optics Fog Fading Models	152
4.6		Fading Models for NLOS Links	153



4.6.1	NLOS Multipath Fading Models	154
4.6.1.1	Rayleigh Distribution	154
4.6.1.2	Rician Distribution	157
4.6.1.3	Nakagami Distribution	158
4.6.2	NLOS Shadow Fading Models	160
4.6.3	Composite Fading–Shadowing Distributions	161
4.7	Conclusion	162
4.8	References	163
<b>5</b>	<b>Propagation Environment Models</b>	<b>165</b>
5.1	Introduction	165
5.2	Topography	166
5.2.1	Topographic Maps	166
5.2.2	Terrain DEMs	167
5.2.3	DEM Data from Satellite and Aerial Imagery	169
5.3	Buildings and Other Structures	171
5.3.1	Vector Building Databases	172
5.3.2	Canopy Building Databases	173
5.3.3	System Analysis Errors from Using Canopy Databases	175
5.4	Morphology (Land Use/Land Cover or Clutter)	178
5.5	Atmospheric and Meteorology Factors	179
5.5.1	Atmospheric Refractivity	180
5.5.2	Rain Rates	180
5.5.3	Fog Data	181
5.6	Mobile Elements of the Propagation Environment	181
5.7	Mapping Fundamentals	182
5.7.1	Spheroids, Ellipsoids, and Geoids	183
5.7.2	Geodetic Systems, Datums, and Datum Transformations	183
5.7.3	Map Projections	186
5.7.4	Coordinate Systems	187
5.8	Conclusions	187
5.9	References	188
<b>6</b>	<b>Fixed Wireless Antenna Systems</b>	<b>189</b>
6.1	Introduction	189
6.2	Antenna System Fundamentals	190
6.2.1	Radiation from an Elemental Dipole Antenna	192
6.2.2	Directivity and Gain	194
6.2.3	Antenna Radiation Patterns	195
6.2.4	Polarization	197
6.2.5	Antenna Efficiency and Bandwidth	199
6.2.6	Electrical Beamtilt, Mechanical Beamtilt, and Null Fill	201
6.2.7	Reciprocity	202

---

6.3	Fixed Narrow Beam Antennas	202
6.3.1	Horn Antennas	203
6.3.2	Parabolic and Other Reflector Antennas	205
6.4	Fixed Broad Beam Antennas	208
6.4.1	Horn Antennas for Hub Sectors Above 10 GHz	209
6.4.2	Hub Sector Antennas for MMDS and U-NII Bands	209
6.4.2.1	Linear Antenna Arrays	210
6.4.2.2	Planar Antenna Arrays	212
6.5	Diversity Antenna Systems	214
6.5.1	Empirical Microwave Link Diversity Improvement	217
6.6	Adaptive Antennas	217
6.6.1	Optimum Combining	219
6.7	MIMO Antenna Systems	223
6.8	Waveguides and Transmission Lines	226
6.8.1	Waveguides	227
6.8.2	Transmission Lines	228
6.9	Radomes	229
6.10	Engineered and <i>Ad Hoc</i> Antenna Installations	231
6.11	Conclusions	232
6.12	References	233
<b>7</b>	<b>Modulation, Equalizers, and Coding</b>	<b>235</b>
7.1	Introduction	235
7.2	Digital Modulation – Amplitude, Frequency, and Phase	236
7.3	Fixed Broadband Wireless Modulation Methods	237
7.3.1	BPSK, QPSK, $\pi/4$ -DQPSK	238
7.3.2	16QAM, 64QAM, and 256QAM	239
7.3.3	Orthogonal Frequency Division Multiplexing (OFDM)	241
7.3.3.1	OFDM Peak-to-Average Power Ratio	244
7.4	Error Performance with Noise and Interference	244
7.4.1	Error Performance with Gaussian Noise Only	245
7.4.2	Error Performance with Noise and Constant Amplitude Interference	248
7.4.2.1	16QAM with Noise and Interference	250
7.4.2.2	16QAM with 16QAM Interference	253
7.4.2.3	Coherent QPSK with Noise and Interference	253
7.4.2.4	Differential QPSK with Noise and Interference	256
7.4.3	Error Performance with Flat-Fading Signal and Interference	256
7.4.3.1	Noise Approximation of Interference	257
7.4.4	Error Performance with Frequency Selective Signal Fading	257
7.5	Equalizers	259
7.5.1.1	Time Domain Symbol Equalizers	259
7.5.1.2	Frequency Domain Equalizers (FDE)	261

7.6	Coding Techniques and Overhead	262
7.6.1	Block Codes	263
7.6.1.1	Cyclic Codes	264
7.6.2	Concatenated Codes	265
7.6.3	Interleaving	265
7.6.4	Convolutional Codes	266
7.6.5	Trellis-Coded Modulation (TCM)	267
7.6.6	Coding Gain	268
7.6.7	Space-Time Codes	269
7.7	Conclusion	272
7.8	References	273
<b>8</b>	<b>Multiple-Access Techniques</b>	<b>275</b>
8.1	Introduction	275
8.1.1	Intersystem Multiple Access	276
8.1.2	Intrasystem Multiple Access	277
8.1.3	Duplexing	277
8.2	Frequency Division Multiple Access (FDMA)	278
8.2.1	FDMA Interference Calculations	280
8.2.1.1	Noise Power	280
8.2.1.2	Cochannel and Adjacent Channel Interference	282
8.2.1.3	Multiple Interferers in LOS Networks	284
8.2.2	Spectrum Utilization	286
8.3	Time Division Multiple Access (TDMA)	286
8.3.1	TDMA Intercell Interference	288
8.4	Code Division Multiple Access (CDMA)	290
8.4.1	Frequency-Hopping Spread Spectrum (FHSS)	290
8.4.2	Direct Sequence (DS) Spread Spectrum	291
8.4.3	Downlink Interference Calculations	293
8.4.3.1	Downlink Pilot Channel $E_c/I_0$	294
8.4.3.2	Downlink Traffic Channel $E_b/N_0$	294
8.4.4	Uplink Interference Calculations	295
8.4.4.1	Rake Receiver	297
8.4.5	Joint (Multiuser) Detection	298
8.4.6	CDMA Broadband Standards	299
8.5	Space Division Multiple Access (SDMA)	302
8.6	Carrier Sense Multiple Access (CSMA)	304
8.7	Multiple Access with OFDM	305
8.7.1	Multicarrier CDMA (MC-CDMA)	306
8.7.2	Orthogonal Frequency Division Multiple Access (OFDMA)	307
8.7.3	OFDM with TDMA	307
8.7.4	OFDM with CSMA/CA (IEEE 802.11a)	308

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8.7.5	OFDM with SDMA	308
8.7.6	OFDM Multiple-Access Standards	308
8.8	Duplexing Methods	309
8.8.1	Frequency Division Duplexing (FDD)	310
8.8.2	Time Division Duplexing (TDD)	311
8.8.2.1	TDD Interference Calculations	312
8.9	Capacity	313
8.9.1	Shannon Theoretical Channel Capacity	314
8.9.2	Capacity in Interference-Limited, Multiuser Systems	315
8.9.3	User Capacity	318
8.9.4	Commercial Capacity	318
8.10	Conclusion	319
8.11	References	319
<b>9</b>	<b>Traffic and Application Mix Models</b>	<b>321</b>
9.1	Introduction	321
9.2	Traffic Geographic Distribution Models	323
9.2.1	Residential Demographic Data	323
9.2.2	Business Demographic Data	326
9.2.3	Land Use Data	329
9.2.4	Building Data	330
9.2.5	Aerial Photographs	331
9.3	Service and Application Types	332
9.4	Circuit-Switched Traffic Models	333
9.4.1	Circuit-Switched Quality of Service (QoS)	334
9.4.1.1	Erlang B Blocking Probability	334
9.4.1.2	Erlang C Blocking Probability	335
9.5	Packet-Switched Traffic Models	335
9.5.1	Self-Similar Data Characteristics	337
9.5.2	Packet Probability Distributions	338
9.5.2.1	Packet Size Distribution	338
9.5.2.2	Packets and ADU's	339
9.5.2.3	Packet Interarrival Time Distribution	339
9.5.2.4	Distribution of the Number of Packets and the Packet Sessions	340
9.5.2.5	Packet Session Interval Distribution	340
9.5.2.6	Packet Session Arrival Distribution	341
9.5.3	ETSI Web-Browsing Packet Transmission Model	342
9.5.4	Random Packet Cluster Transmission Model	342
9.6	Multisource Traffic Density Models	342
9.6.1	Aggregate Data Rate Statistics	344
9.6.2	Aggregate Data Rate Statistics with Packet Queuing (Delay)	346
9.6.2.1	Internet Latency	349

9.6.3	Throughput	349
9.7	Application Mix	351
9.8	Broadcast and On-Demand Video Applications	353
9.9	Conclusions	354
9.10	References	355
<b>10</b>	<b>Single and Multilink System Design</b>	<b>357</b>
10.1	Introduction	357
10.2	Long-Range LOS Links over Mixed Paths	358
10.2.1	Path Profile Clearance Analysis	359
10.2.1.1	Path Clearance Validation	361
10.2.2	Reflection Point Analysis	361
10.2.3	Link Budget	363
10.2.4	Fade Margin	368
10.2.5	Link Availability (Reliability)	369
10.2.6	Multipath Fade Outage	369
10.2.7	Diversity Improvement in Flat Fading Links	371
10.2.7.1	Space Diversity	371
10.2.7.2	Polarization Diversity	373
10.2.8	Dispersive (Frequency-Selective) Fade Margin	374
10.2.9	Diversity Improvement for Dispersive (Frequency-Selective) Channels	375
10.2.9.1	Frequency Diversity	376
10.2.9.2	Angle Diversity	376
10.2.10	Rain Fade Outage	376
10.2.10.1	Link Availability with Crane Rain Fade Model	377
10.2.10.2	Link Availability with the ITU-R Rain Fade Model	377
10.2.11	Composite Link Availability	378
10.2.12	Equipment Failures	379
10.3	Short-Range LOS Links in Urban Environments	380
10.3.1	Building Path Profiles	380
10.3.2	Short-Range Fading	381
10.3.3	Short-Range Urban Rain Fading	383
10.3.4	Interference Diffraction Paths over Building Edges	384
10.3.5	Urban Link Availability	385
10.3.6	Free Space Optic (FSO) Link Design	386
10.3.7	'Riser' and FSO Backup Links	387
10.4	NLOS Links in Urban and Residential Environments	387
10.4.1	Basic NLOS Path Loss	389
10.4.2	Antenna Gain in Scattering Environments	391
10.4.3	Location Variability	392
10.4.4	Time Variability (Narrowband Fading)	393

10.4.5	Time Dispersion and Arrival Angles	393
10.4.6	Channel Spatial Correlation	395
10.5	Link Adaptation	396
10.6	Multihop (Tandem) Link Systems	397
10.6.1	Passive Repeaters	398
10.7	Consecutive Point Networks	400
10.8	Mesh Networks	401
10.8.1	NLOS Mesh Networks	403
10.9	Conclusions	404
10.10	References	405
<b>11</b>	<b>Point-to-Multipoint (PMP) Network Design</b>	<b>407</b>
11.1	Introduction	407
11.2	LOS Network Design	409
11.2.1	Hub Site Selection	410
11.2.1.1	Visibility/Shadowing Analysis	410
11.2.1.2	Algorithms for Efficient Multiple Hub Site Selections	413
11.2.1.3	Hub Traffic/Revenue Potential Assessment	415
11.2.2	Hub Sector Configuration	416
11.2.3	CPE Best Server Hub Sector Assignments	420
11.2.4	Signal Distribution from a Rooftop	423
11.3	LOS Network Performance Analysis	423
11.3.1	Interference Analysis	424
11.3.1.1	Reduced Cross-Polarization Discrimination During Rain Fades	425
11.3.1.2	Correlated Rain Fades	425
11.3.1.3	Uplink Interference Calculations	426
11.3.1.4	Impact of Automatic Power Control (APC)	427
11.3.1.5	Coupled Links	427
11.3.2	Estimating Hub Sector Capacity Requirements	428
11.3.3	LOS Network Performance Statistics	431
11.4	NLOS Network Design	432
11.4.1	NLOS Hub Site Selection	432
11.4.1.1	Coverage/Service Area Calculations	432
11.4.1.2	Automatic Algorithms for Hub Site Selections	434
11.4.2	CPE Locations	435
11.5	NLOS Network Performance Analysis	435
11.5.1	Downlink Signals for Basic NLOS Interference Analysis	436
11.5.1.1	Downlink Interference Analysis	436
11.5.1.2	Uplink Interference Analysis	438
11.5.2	Dynamic Monte Carlo Interference Simulation	439
11.5.3	Estimating Hub Sector Capacity Requirements	442



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11.5.4	NLOS Network Performance Statistics	443
11.5.5	W-CDMA Interference and Capacity	444
11.6	Network Design Revisions	444
11.6.1	PMP Network Coverage Deficiencies	445
11.6.2	High Frame Error Rates	445
11.6.3	High Packet Delay Times	445
11.7	Conclusion	446
11.8	References	447
<b>12</b>	<b>Channel Assignment Strategies</b>	<b>449</b>
12.1	Introduction	449
12.2	Frequency, Time Slot, and Code Planning	451
12.3	Fixed Assignments for Point-to-Point LOS Networks	451
12.3.1	Multiple Interferers on a Channel	454
12.3.2	Impact of Automatic Power Control (APC)	455
12.4	Fixed Assignments for LOS PMP Networks	455
12.4.1	LOS Networks	455
12.4.2	Conventional Cluster Frequency Planning	459
12.4.3	Impact of Adaptive Antennas in Fixed LOS Networks	460
12.4.4	Demand-Based Fixed LOS Assignments	461
12.4.5	Number of CPEs Supported in Fixed LOS Networks	464
12.5	Fixed Assignments for NLOS PMP Networks	464
12.5.1	Target S/I Ratio	465
12.5.2	Frequency Reuse Distance	466
12.5.3	Cell Layout and Channel Assignment Patterns	467
12.6	Optimizing Channel Assignments in NLOS Networks	469
12.6.1	Steepest Descent Method	470
12.6.2	Simulated Annealing Method (SA)	471
12.6.3	Genetic or Evolutionary Algorithm Method	471
12.6.4	Channel Assignments in W-CDMA Systems	472
12.7	NLOS Network Capacity	472
12.8	Dynamic Frequency Channel Assignments	473
12.8.1	Centralized DCA	473
12.8.2	Decentralized DCA	474
12.8.3	Channel Segregation	475
12.8.4	Dynamic Packet Assignment	476
12.8.5	DCA for UTRA-TDD Networks	477
12.9	Other Capacity Enhancement Techniques	478
12.9.1	Adaptive Antennas	478
12.9.2	Joint Detection	478
12.9.3	Link Adaptation	479
12.10	Spectrum Vectors, Occupancy, and Utilization	479
12.10.1	Spectrum Vectors	480
12.10.2	Spectrum Occupancy	482

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12.10.3	Communication Value	482
12.10.4	Spectrum Utilization	483
12.10.5	Spectrum Capacity	484
12.11	Conclusions	484
12.12	References	485
<b>Appendix A. Atmospheric and Rain Data</b>		<b>487</b>
<b>Appendix B. PDF of a Signal with Interference and Noise</b>		<b>497</b>
B.1	Introduction	497
B.2	References	500
<b>Index</b>		<b>501</b>



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# Preface

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The growing demand for high-speed data connections to serve a variety of business and personal uses has driven an explosive growth in telecommunications technologies of all sorts including optical fiber, coaxial cable, twisted-pair telephone cables, and wireless. Nations have recognized that telecommunications infrastructure is as significant as roads, water systems, and electrical distribution in supporting economic growth. In developing countries it is not particularly unusual to see cell phone service in a town or village that does not yet have a water or sewer system. In the United States, recent government initiatives have recognized the importance of broadband telecommunications to economic growth.

This book focuses on fixed broadband wireless communications – a particular sector of the communication industry that holds great promise for delivering high-speed data to homes and businesses in a flexible and efficient way. The concept of ‘broadband’ communications is a relative one. Compared to the 1200-baud modems commonly used 20 years ago, today’s dial-up phone connections with 56-kbps modems are ‘broadband’. The demands and ambitions of the communication applications and their users have expanded, and will continue to expand, on what is meant by ‘broadband’. The term is evolving, as is the technology that is classified as broadband. Nevertheless, for the purposes of this book I will use the somewhat arbitrary definition that broadband wireless systems are those designed for, and capable of handling baseband information data rates of 1 Mbps or higher, knowing that future developments may well move this threshold to 5 or 10 Mbps and beyond. The term ‘broadband’ also has an engineering significance that will be discussed in some detail in this book. Broadband wireless channels, as distinguished from narrowband channels, are those whose transfer characteristics must be dealt with in a particular way, depending on the information transmission speed and the physical characteristics of the environment where the service is deployed.

The term ‘fixed’ has also become somewhat nebulous with the technological developments of the past few years. Whereas fixed and mobile were previously well-understood differentiators for system types, we now have intermediate types of network terminals including fixed, portable, nomadic, and mobile, among others. Recent system standards such as those for 3G UMTS W-CDMA define different service levels and data rates depending on whether the user is in a fixed location, walking, or moving at high speed. This trend portends a convergence of fixed and mobile system types whose operation and availability are largely transparent to the application users. As will be shown, whether the system user is at a fixed location or in motion affects several decisions about the system design, the most appropriate technology, and the quality and performance that can be expected from a wireless application.

Although there have been a few books recently written on broadband, and specifically wireless broadband, in general they have been intended for non-technical audiences.

This book is intended for engineers who are faced with designing and deploying fixed broadband wireless systems, and who must also have sufficient understanding of the theory and principles on which the designs are based to formulate creative solutions to special engineering problems that they will eventually face. Along with generally accepted design assumptions and simplifications, the underlying theory and requisite mathematics are included where necessary to provide this foundation knowledge.

In addition to design engineers who deal with fixed broadband wireless systems on a daily basis, this book is also well suited to graduate and post-graduate level courses that are focused on wireless communications engineering. Wireless communication system design and planning is an increasingly important area that warrants serious academic treatment.

This book also covers some areas that have not classically fallen in the domain of wireless RF engineers; in particular, traffic modeling, environment databases, and mapping. Wireless system design is driven by the commercial requirements of the system operators who ultimately build viable businesses by successfully serving the traffic demands of the customers in their service areas. Detailed statistical modeling of packet-based traffic for a variety of applications (e-mail, web-browsing, voice, video streaming) is an essential consideration in fixed broadband system design if the operator's capacity and quality of service objectives are to be achieved.

The chapters in this book are organized with the fundamentals of electromagnetic propagation, channel and fading models, antenna systems, modulation, equalizers and coding treated first since they are the building blocks on which all wireless system designs are based. Chapters on multiple access methods and traffic modeling follow. The remaining chapters set forth the specific details of many types of line-of-sight (LOS) and non-line-of-sight (NLOS) systems, including elemental point-to-point links as well as point-to-multipoint, consecutive point, and mesh networks. Because of their importance, a separate chapter is devoted to designing both LOS and NLOS point-to-multipoint networks. The final chapter deals with the important subject of channel assignment strategies where the capacity and service quality of the wireless network is ultimately established.

Fixed wireless design relies on a number of published sources for data and algorithms. For convenience, the essential data, such as rain rate tables and maps, is included in the Appendices. In general, the referenced publications chosen throughout are currently available books or journal papers which are readily accessible in academic libraries or on-line. For the most recent or unique work, technical conference papers are also utilized.

A book of this type is clearly not a solo effort. I would like to thank several people who offered valuable comments, including Tim Wilkinson for reviewing Chapters 7 and 8, George Tsoulos for reviewing Chapter 6, and Jody Kirtner for reviewing Chapter 5, and for her efforts in proofreading the entire manuscript. Creating and refining a technical work such as this book is an evolutionary process where comments, suggestions, and corrections from those using it are most welcome and encouraged. I hope and anticipate that this book will prove to be a worthwhile addition to the engineering libraries of those who design, deploy, and manage fixed broadband wireless systems.

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