

802.16.2™

**IEEE Recommended Practice for
Local and metropolitan area networks**

Coexistence of Fixed Broadband Wireless Access Systems

IEEE Computer Society
and the
IEEE Microwave Theory and Techniques Society

Sponsored by the
LAN/MAN Standards Committee



Published by
The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

17 March 2004

Print: SH95215
PDF: SS95215

*Recognized as an
American National Standard (ANSI)*

IEEE Std 802.16.2™-2004(R2010)
(Revision of IEEE Std 802.16.2-2001)

**IEEE Recommended Practice for
Local and Metropolitan Area Networks**

Coexistence of Fixed Broadband Wireless Access Systems

Sponsors

**LAN/MAN Standards Committee
of the
IEEE Computer Society**

and the

IEEE Microwave Theory and Techniques Society



Approved 12 May 2004
American National Standards Institute

Reaffirmed 25 March 2010
Approved 9 February 2004
IEEE-SA Standards Board

Grateful acknowledgment is made to the European Telecommunications Standards Institute for the permission to use the following source material:

Figure 2 and Figure 3 from ETSI EN 301 390 V1.1.1, Fixed Radio Systems; Point-to-point and Point-to-Multipoint Systems; Spurious emissions and receiver immunity at equipment/antenna port of Digital Fixed Radio Systems.

Abstract: This recommended practice provides recommendations for the design and coordinated deployment of fixed broadband wireless access systems in order to control interference and facilitate coexistence. It analyzes appropriate coexistence scenarios and provides guidance for system design, deployment, coordination, and frequency usage. It generally addresses licensed spectrum between 2 GHz and 66 GHz, with a detailed emphasis on 3.5 GHz, 10.5 GHz, and 23.5 – 43.5 GHz.

Keywords: coexistence, fixed broadband wireless access (FBWA), interference, local multipoint distribution service (LMDS), millimeter waves, multichannel multipoint distribution service (MMDS), microwaves, multipoint (MP), point-to-multipoint (PMP), radio, wireless metropolitan area network (WirelessMAN™) standard

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2004 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 17 March 2004. Printed in the United States of America.

IEEE, 802, and WirelessMAN are registered trademarks in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics Engineers, Incorporated.

Second printing 27 March 2006.

Print: ISBN 0-7381-3985-8 SH95215
PDF: ISBN 0-7381-3986-6 SS95215

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied “**AS IS**.”

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854
USA

Note: Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Authorization to photocopy portions of any individual standard for internal or personal use is granted by the Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; (978) 750-8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

(This introduction is not a part of IEEE Std 802.16.2-2003, IEEE Recommended Practice for Local and Metropolitan Area Networks—Coexistence of Fixed Broadband Wireless Access Systems.)

This recommended practice revises IEEE Std 802.16.2TM-2001. The original document covered 10–66 GHz frequencies in general, with a focus on 23.5–43.5 GHz frequencies. The activity paralleled the project in the IEEE 802.16 Working Group to develop IEEE Std 802.16TM-2001, which specified the WirelessMAN air interface from 10 GHz to 66 GHz. As the Working Group expanded the scope of the WirelessMAN air interface to include 2–11 GHz frequencies, in the project leading to the IEEE Std 802.16aTM amendment, the working group took up the task of developing a parallel extension of its coexistence work to include 2–11 GHz frequencies. This revision includes the results of that effort, along with additional material on coexistence with point-to-point (PTP) systems.

Notice to users

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/updates/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/interp/index.html>.

Participants

This recommended practice was developed by the IEEE 802.16 Working Group on Broadband Wireless Access, which is responsible for wireless metropolitan area network (WirelessMANTM) standards. The IEEE 802.16 Working Group had the following officers:

Roger B. Marks, *Chair*
Kenneth Stanwood, *Vice Chair*
Carl Eklund, *prior Vice Chair (until 25 July 2003)*
Dean Chang, *Secretary*

Primary development was carried out by the working group's Task Group 2, which had the following officers:

Philip Whitehead, *Chair, Secretary*
Roger B. Marks, *Technical Editor, Final Stages*
Nico J.M. van Waes, **Reza Arefi**, *Technical Editors, Earlier Drafts*

This recommended practice is a revision of IEEE Std 802.16.2-2001. The following served in key capacities at the time that standard completed working group letter ballot:

Roger B. Marks, *Chair, IEEE 802.16 Working Group on Broadband Wireless Access*
Brian G. Kiernan, *Vice Chair, IEEE 802.16 Working Group*
Carl J. Bushue, *Secretary, IEEE 802.16 Working Group*
Philip Whitehead, *Chair, Task Group 2*
Roger B. Marks, *Technical Editor*
Muya Wachira, Vito Scaringi, Rebecca Chan, *Prior Technical Editors*
Rémi Chayer, Jack Garrison, Barry Lewis, Paul Thompson, Philip Whitehead, and Robert Whiting,
Ballot Resolution Committee

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which the draft of IEEE Std 802.16.2-2001 was approved:

Song An
Reza Arefi
Jori Arrakoski
Arun V. Arunachalam
Eli Avivi
Ian Baragar
C. R. Baugh
Carlos Belfiore
Anader Benyamin-Seeyar
Tom Bilotta
Baruch Buskila
Dean Chang
Naftali Chayat
Rémi Chayer
Mary Condie
José Costa
Bruce Currivan
Amos Dotan
Brian Eidson
Carl Eklund
David Falconer
George Fishel
Adrian Florea
Robert Foster
Avraham Freedman
G. Jack Garrison
Richard Germon

Phil Guillemette
Zion Hadad
Baruch Halachmi
Michael Hamilton
Srinath Hosur
Coleman Hum
Wayne Hunter
Eric Jacobsen
Hamadi Jamali
Jacob Jorgensen
Inchul Kang
Mika Kasslin
Brian G. Kiernan
Itzik Kitroser
Allan Klein
Jay Klein
Tom Kolze
Demosthenes Kostas
John Langley
Yigal Leiba
Barry Lewis
John Liebetreu
Lars Lindh
Fred Lucas
Scott Marin
Roger B. Marks
Andy McGregor
Ronald Meyer

Andrew Middleton
Anton Monk
William Myers
Uzi Padan
Yunsang Park
Brian Petry
Moshe Ran
Stanley Reible
Guy Resheff
David Ribner
Eugene Robinson
Walt Roehr
Durga Satapathy
Glen Sater
Vito Scaringi
David Schafer
Menashe Shahar
Chet Shirali
George Stamatelos
Kenneth Stanwood
Paul Thompson
David Trinkwon
Nico van Waes
Muya Wachira
Philip Whitehead
Chaoming Zeng
Juan-Carlos Zuniga

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the working group letter ballot in which the draft of this recommended practice was approved. Balloters may have voted for approval, disapproval, or abstention.

Aditya Agrawal	Grant Hulse	Kenneth Peirce
Gordon Antonello	David Husson	Subbu Ponnuswamy
Reza Arefi	Jacob Jorgensen	Moshe Ran
Jori Arrakoski	Tal Kaitz	Gene Robinson
Malik Audeh	Mika Kasslin	Shane Rogers
Eli Avivi	Phil Kelly	Vincentzio Roman
Anader Benyamin-Seeyar	Ofer Kelman	Amir Sarajedini
Carl Bushue	Brian G. Kiernan	Octavian Sarca
Baruch Buskila	Itzik Kitroser	Durga Satapathy
Dean Chang	Jerome Krinock	Randall Schwartz
Yuankai Chang	Jonathan Labs	Yossi Segal
David Chauncey	John Langley	James Simkins
Naftali Chayat	Yigal Leiba	Sean Sonander
Rémi Chayer	Barry Lewis	Kenneth Stanwood
Brian Eidson	Lars Lindh	Paul Struhsaker
Henry Eilts	Hui-Ling Lou	Shawn Taylor
Carl Eklund	Heinz Lycklama	Jose Tellado
Avraham Freedman	Roger B. Marks	David Trinkwon
Andrew Garrett	Russell McKown	Nico van Waes
G. Jack Garrison	Apurva Mody	Arthur Wang
Marianna Goldhammer	Ronald Murias	Robert Ward
Zion Hadad	Robert Nelson	Philip Whitehead
	Mike Paff	

The following members of the IEEE balloting committee voted on this recommended practice. Balloters may have voted for approval, disapproval, or abstention.

John Adams	Yeou-Song Lee	Eugene Robinson
Edward Carley Jr	Jan-Ray Liao	Thomas Sapiano
Remi Chayer	Christina Lim	John Sarallo
Aik Chindapol	Randolph Little	John Sargent
Keith Chow	Gregory Luri	Neil Shipp
Todor Cooklev	Ryan Madron	Gil Shultz
Jose M. Costa	Roger B. Marks	Yoram Solomon
Thomas Dineen	Ingolf Meier	Kenneth Stanwood
Dr. Sourav Dutta	George Miao	Adrian Stephens
Avraham Freedman	Apurva Mody	Carl Stevenson
Ernesto Garcia	Narayanan Murugesan	Scott Valcourt
Theodore Georgantas	Michael Newman	Nico van Waes
Andrew Germano	Paul Nikolich	Joan Viaplana
James Gilb	Stephen Palm	Hung-yu Wei
Brian G. Kiernan	Ashley Peacock	Patrick Yu
Pi-Cheng Law	Subbu Ponnuswamy	Oren Yuen
	Vikram Punj	

When the IEEE-SA Standards Board approved this recommended practice on 09 February 2004, it had the following membership:

Don Wright, *Chair*
TBD, *Vice Chair*
Judith Gorman, *Secretary*

Chuck Adams,
Stephen Berger
Mark D. Bowman
Joseph Bruder
Bob Davis
Arnold M. Greenspan
Mark S. Halpin
Raymond Hapeman
Richard J. Holleman

Richard Hulett
Lowell Johnson
Hermann Koch
Thomas J. McGean
Steve M. Mills
Daleep Mohla
Paul Nikolic
T. W. Olsen
Ronald C. Petersen

Gary S. Robinson
Frank Stone
Malcolm V. Thaden
Doug Topping
Joe D. Watson
Roberto de Boisson
Julian Forster*
Joseph Koepfinger*

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish K. Aggarwal, *NRC Representative*
Richard DeBlasio, *DOE Representative*
Alan Cookson, *NIST Representative*

Michelle Turner
IEEE Standards Project Editor

CONTENTS

1. Overview	1
1.1 Scope	2
1.2 Purpose	2
2. Normative references	2
3. Definitions and Abbreviations	3
3.1 Definitions	3
3.2 Abbreviations	6
4. System overview	7
4.1 System architecture	8
4.1.1 PMP systems	9
4.1.2 Mesh systems	9
4.1.3 Antenna subsystems	9
4.2 Interference scenarios	10
4.2.1 Forms of interference	10
4.2.2 Acceptable level of interference	11
4.2.3 Interference paths	11
4.2.3.1 Victim BS	11
4.2.3.2 Victim SS	13
4.2.3.3 Victim omnidirectional mesh node	14
5. Coexistence of FBWA systems in 23.5 GHz – 43.5 GHz	15
5.1 Introduction	15
5.2 Recommendations	16
5.2.1 Recommendation 1-1	16
5.2.2 Recommendation 1-2	17
5.2.3 Recommendation 1-3	17
5.2.4 Recommendation 1-4	17
5.2.5 Recommendation 1-5	17
5.2.6 Recommendation 1-6	18
5.2.7 Recommendation 1-7	18
5.2.8 Recommendation 1-8	18
5.2.9 Recommendation 1-9	18
5.2.10 Recommendation 1-10	19
5.3 Suggested guidelines for geographical and frequency spacing	19
5.4 Medium overview	19
5.5 Equipment design parameters	20
5.5.1 Transmitter design parameters	20
5.5.1.1 Maximum EIRP psd limits	20
5.5.1.1.1 BS	21
5.5.1.1.2 SS	22
5.5.1.1.3 Repeaters (RSs)	22
5.5.1.1.4 In-band intercell links	22
5.5.1.1.5 Uplink power control	22
5.5.1.1.6 Downlink power control	23
5.5.1.2 Frequency tolerance or stability	23
5.5.1.3 OOB unwanted emissions	23

5.5.1.4	Unwanted emission levels specified in ETSI standards	23
5.5.2	Receiver design parameters	24
5.5.2.1	CoCh interference tolerance	25
5.5.2.1.1	Base station (BS)	25
5.5.2.1.2	Subscriber station (SS).....	25
5.5.2.1.3	Link availability in a joint C/N + C/I transmission environment	26
5.5.2.2	AdjCh desired to undesired signal level tolerance.....	27
5.5.2.2.1	BS and SS D/U tolerance.....	27
5.6	Deployment and coordination.....	28
5.6.1	CoCh/adjacent-area case.....	28
5.6.1.1	Methodology	28
5.6.1.2	Coordination trigger.....	29
5.6.2	Same-area/adjacent-frequency case	30
5.6.3	Use of psfd as a coexistence metric	30
5.6.4	Deployment procedure.....	31
5.7	Interference and propagation evaluation/examples of coexistence in a PMP environment	31
5.7.1	Guidelines for geographical and frequency spacing between FBWA systems	31
5.7.1.1	Summary	31
5.7.1.2	Interference mechanisms	31
5.7.1.3	Worst-case analysis.....	32
5.7.1.4	Monte Carlo simulations.....	32
5.7.1.5	IA method	32
5.7.1.6	Interference scenario occurrence probability (ISOP)	32
5.7.1.7	Simulations and calculations	33
5.7.1.8	Variables	34
5.7.1.9	Results of the analysis.....	34
5.7.1.10	CoCh case	34
5.7.1.10.1	BS-to-BS co-polar case with single and multiple interferers	34
5.7.1.10.2	SS-to-BS CoCh case	35
5.7.1.10.3	SS-to-SS CoCh case.....	35
5.7.1.11	Overlapping area case	35
5.7.1.11.1	BS-to-BS interference.....	35
5.7.1.11.2	SS-to-BS interference	36
5.7.1.11.3	SS-to-SS same-area case.....	36
5.8	Mitigation techniques	36
5.8.1	General.....	36
5.8.2	Frequency band plans	36
5.8.3	Service area demarcation	37
5.8.4	Separation distance/power	37
5.8.5	Co-siting of BSs.....	37
5.8.6	Coexistence with PTP systems	37
5.8.7	Antennas	38
5.8.7.1	Antenna-to-antenna isolation.....	38
5.8.7.2	Orientation	38
5.8.7.3	Tilting.....	38
5.8.7.4	Directivity	38
5.8.7.5	Antenna heights	38
5.8.7.6	Future schemes	38
5.8.7.7	Polarization	39
5.8.8	Blockage	39
5.8.9	Signal processing	39
5.8.10	Receiver sensitivity degradation tolerance	39
5.8.11	Subscriber Tx lock to prevent transmissions when no received signal present.....	39
5.8.11.1	Fail-safe	39

6. Coexistence of FBWA systems with PTP links in 23.5 GHz – 43.5 GHz	40
6.1 Recommendations and guidelines	40
6.1.1 Recommendation 2-1	40
6.1.2 Recommendation 2-2	40
6.1.3 Recommendation 2-3	41
6.1.4 Recommendation 2-4	41
6.1.5 Recommendation 2-5	41
6.1.6 Recommendation 2-6	41
6.2 Suggested guidelines for geographical and frequency spacing	41
6.3 System overview (interferer and victim systems).....	42
6.3.1 Interference scenario 1: multiple PTP links in a frequency block	42
6.3.2 Interference scenario 2: individually licensed links	43
6.3.3 System parameters assumed in the simulations	43
6.3.4 Antenna parameters	45
6.3.4.1 Typical PTP link antenna characteristics.....	45
6.3.4.2 Construction of a composite RPE.....	45
6.3.5 Comparison of the composite RPE to standards.....	47
6.4 Interference scenarios	54
6.4.1 Acceptable level of interference	55
6.4.2 Interference paths.....	55
6.4.2.1 Victim BS	55
6.4.2.2 Victim SS.....	55
6.4.2.3 Victim PTP link	55
6.5 Equipment design parameters	56
6.6 Deployment and coordination between PMP and PTP systems	56
6.6.1 CoCh/adjacent-area case	56
6.6.2 Same-area/adjacent-frequency case with individually planned static links.....	56
6.6.3 Example calculations	57
6.6.3.1 Class B1 and Class B2	57
6.6.3.2 Class B3 and Class B4	59
6.6.4 Considerations for deployment	61
6.6.5 Same-area/adjacent-frequency case with multiple PTP link systems operating dynamically.....	62
6.7 Description of interference evaluation and example scenarios	62
6.7.1 Interference mechanisms	62
6.7.2 Simulations and calculations	63
6.7.3 Results of the analysis.....	64
6.7.4 CoCh cases.....	64
6.7.4.1 BS-to-PTP co-polar/CoCh case	64
6.7.4.2 PTP-to-BS co-polar/CoCh case	64
6.7.4.3 SS-to-PTP co-polar/CoCh case.....	65
6.7.4.4 PTP-to-SS co-polar/CoCh case.....	65
6.7.4.5 BS-to-PTP same-area/AdjCh case	65
6.7.4.6 PTP-to-BS same-area/AdjCh case	66
6.7.4.7 SS-to-PTP same-area/AdjCh case	66
6.7.4.8 PTP-to-SS same-area/AdjCh case	66
6.8 Mitigation techniques for coexistence between FBWA and PTP systems.....	67
6.8.1 Impact of buildings and terrain on CoCh interference	67
6.8.2 Simulation results	67
6.8.3 Conclusions.....	68

7. Coexistence of FBWA systems operating in 2–11 GHz licensed bands	68
7.1 Introduction.....	68
7.2 Recommendations	69
7.2.1 Recommendation 3-1	69
7.2.2 Recommendation 3-2	70
7.2.3 Recommendation 3-3	70
7.2.4 Recommendation 3-4	70
7.2.5 Recommendation 3-5	71
7.2.6 Recommendation 3-6	71
7.2.7 Recommendation 3-7	71
7.3 Suggested guidelines for geographical and frequency spacing	72
7.4 System description (interferer and victim systems).....	72
7.4.1 System parameters assumed in the simulations	72
7.4.2 Medium overview	76
7.4.3 Interference scenarios	76
7.5 Deployment and coordination.....	76
7.5.1 Co-frequency/adjacent-area case	76
7.5.1.1 Methodology	76
7.5.1.2 Coordination trigger.....	77
7.5.1.2.1PMP	77
7.5.1.2.2MP-MP (mesh)	78
7.5.2 Same-area/adjacent-frequency case	79
7.6 Coexistence of PMP networks.....	79
7.6.1 Interference mechanisms	79
7.6.2 Worst-case analysis.....	80
7.6.3 Monte Carlo simulations.....	80
7.6.4 Other methods.....	80
7.6.5 Simulations and calculations	80
7.7 Coexistence of mesh networks	81
7.7.1 CoCh intercell interference in a large-scale network.....	81
7.7.2 CoCh internetwork interference between adjacent areas.....	84
7.7.3 AdjCh intercell interference in a large-scale network	84
7.7.4 AdjCh internetwork interference between adjacent areas	85
7.7.5 AdjCh internetwork interference within the same area	85
7.8 Mitigation techniques	85
7.8.1 AA techniques.....	85
7.8.2 Other characteristics of AAs.....	85
Annex A (informative) Bibliography	86
Annex B (informative) Additional material for FBWA systems from 23.5 GHz – 43.5 GHz.....	92
B.1 Test and measurement/hardware parameter summary.....	92
B.1.1 Testing of unwanted emissions	92
B.1.1.1 Methodology	92
B.1.1.2 Single-carrier test	93
B.1.1.3 Multicarrier test.....	94
B.1.2 Measuring frequency stability	94
B.1.3 European conformance test standards	94
B.2 Calculations of psfd	95
B.2.1 In the 20–30 GHz range	95
B.2.2 In the 38–43.5 GHz range	96
B.3 Description of calculations and simulation methods	96

B.3.1	SS-to-BS adjacent-area/same-frequency case	96
B.3.1.1	Simulation model	97
B.3.1.2	Simulation results	97
B.3.2	BS-to-SS same-area/adjacent-frequency case	98
B.3.2.1	Simulation model	98
B.3.2.2	Simulation results	98
B.3.3	SS-to-BS same-area/adjacent-frequency case	99
B.3.3.1	Simulation model	100
B.3.3.2	Simulation results	101
B.3.4	BS-to-SS same-area/AdjCh case, IA method	102
B.3.4.1	Simulation method	102
B.3.4.1.1	Simulation results	102
B.3.5	SS-to-SS same-area/AdjCh case, TDD only	102
B.3.5.1	Simulation method	103
B.3.5.2	Simulation results	103
B.3.6	SS-to-SS CoCh/adjacent-area case (TDD)	103
B.3.6.1	Simulation method	104
B.3.6.2	Simulation results	104
B.3.7	SS-to-BS CoCh/adjacent-area case	104
B.3.7.1	Simulation method	104
B.3.7.2	Simulation results	104
B.3.8	BS-to-BS CoCh case with multiple interferers	105
B.3.8.1	Simulation method	105
B.3.8.2	Simulation results	106
B.3.9	Mesh-to-PMP-BS CoCh/adjacent-area case	106
B.3.9.1	Simulation method	106
B.3.9.2	Simulation results	107
B.3.10	Mesh-to-PMP-SS CoCh/adjacent-area case	107
B.3.10.1	Simulation method	107
B.3.10.2	Simulation results	107
B.3.11	Mesh-to-PMP-BS same-area/adjacent-frequency case	108
B.3.11.1	Simulation method	108
B.3.11.2	Simulation results	108
B.3.12	Mesh-to-PMP-SS same-area/adjacent-frequency case	108
B.3.12.1	Simulation method	108
B.3.12.2	Simulation results	109
B.3.13	General scenario: same-area/adjacent-frequency case	109
B.3.13.1	Simulation method	109
B.3.13.2	Simulation results	110
B.4	Work of other bodies	111
B.4.1	ETSI Working Party TM4	111
B.4.1.1	Interference classes	111
B.4.1.2	Deployment scenario assumptions	112
B.4.1.3	Methodology	112
B.4.1.4	Resultant considerations	113
B.4.1.5	Worked examples	113
B.4.2	Industry Canada (IC)	114
B.4.3	Radio Advisory Board of Canada (RABC)	114
B.4.4	UK Radiocommunications Agency (UK-RA)	114
B.4.5	European Conference of Postal and Telecommunication Administrations/ European Radiocommunications Committee (CEPT/ERC)	115
B.5	UK-RA coordination process	115
B.5.1	Introduction	115
B.5.2	Coordination triggers	115

B.5.3	Application of the coordination distance and psfd triggers.....	115
B.5.4	Trigger values.....	116
B.5.5	Worst-case interferer calculations	116
B.5.5.1	BS to BS	116
B.5.5.2	SS interference	117
B.5.6	Parameter values used for trigger derivation and simulations	118
B.6	IC coordination process	119
B.7	ICL.....	119
B.7.1	Description	119
B.7.2	NFD.....	120
B.7.3	Isolation.....	121
Annex C (informative) Additional material for FBWA with PTP systems from 23.5 GHz – 43.5 GHz....		122
C.1	Sample 38 GHz psfd calculations	122
C.1.1	38 GHz: PMP BS Tx into victim PTP link	122
C.1.2	38 GHz: PTP link Tx into victim PMP BS and victim PTP link	123
C.2	Calculations and simulation methods for PMP-to-PTP interference.....	123
C.2.1	PMP-BS/SS-to-PTP-link adjacent-area/same-channel case	123
C.2.1.1	Simulation method	123
C.2.1.2	Results.....	124
C.2.2	PTP-link-to-PMP-BS/SS adjacent-area/same-channel case	124
C.2.2.1	Simulation method	125
C.2.2.2	Results when the BS is the victim.....	126
C.2.2.3	Results when the SS is the victim	126
C.2.3	PMP-BS/SS-to/from-PTP-link same-area/AdjCh case.....	127
C.2.4	PMP-BS/SS-to-multiple-PTP-link-system adjacent-area/same-channel case ..	127
C.2.4.1	Simulation method	127
C.2.5	Results when the BS is the interferer	128
C.2.6	Results when the SS is the interferer.....	128
C.2.7	Impact of buildings and terrain	128
C.2.7.1	Summary of simulation results.....	129
C.2.8	Multiple-PTP-link-system-into-PMP-system adjacent-area/CoCh case.....	129
C.2.8.1	Simulation method	129
C.2.8.2	Interfering power calculation	130
C.2.8.3	Simulation results for victim BS	130
C.2.8.4	Simulation results for victim SS	131
C.2.8.5	Conclusions	132
C.2.9	PMP-system-into-multiple-PTP-link-system same-area/AdjCh case.....	132
C.2.9.1	Simulation method	132
C.2.9.2	Results of simulations	133
C.2.9.3	Conclusions for the PMP-to/from-PTP scenarios	133
C.2.10	Multilink-PTP-system-into-PMP-system same-area/AdjCh case	134
C.2.10.1	Simulation method	134
C.2.10.2	Interference to PMP BS	134
C.2.10.3	Interference to PMP SS.....	135
Annex D (informative) Additional material for FBWA systems in 2–11 GHz licensed bands		136
D.1	Sample 3.5 GHz psfd calculations	136
D.1.1	Thresholds	136
D.1.2	PMP BS into victim PMP SS	136
D.2	Description of calculations and simulation methods	136
D.2.1	Description of simulation parameters	136

D.2.2	Adjacent-area/same-frequency case	138
D.2.2.1	Horizon distance and diffraction loss.....	138
D.2.2.2	Outbound BS-to-SS interference.....	141
D.2.2.3	Simulation results.....	141
D.2.3	Inbound SS-to-BS interference	142
D.2.3.1	Simulation model	142
D.2.3.2	Simulation results.....	142
D.2.4	BS-to-BS interference	143
D.2.4.1	Simulation model	143
D.2.4.2	Simulation results.....	143
D.2.5	SS-to-SS interference	143
D.2.5.1	Analysis model and conclusions	143
D.2.6	Same-area/adjacent-frequency case	144
D.2.6.1	Rain attenuation computational procedure.....	146
D.2.6.2	Outbound same-area BS-to-SS interference	147
D.2.6.2.1	Simulation model.....	147
D.2.6.2.2	Simulation results.....	147
D.2.6.3	Inbound same-area SS-to-BS interference	148
D.2.6.3.1	Simulation model.....	148
D.2.6.3.2	Simulation results.....	149
D.2.6.4	Same-area BS-to-BS interference	149
D.2.6.4.1	Simulation model.....	149
D.2.6.4.2	Simulation results.....	149
D.2.6.5	Same-area SS-to-SS interference	150
D.2.6.5.1	Analysis model and conclusions	150
D.3	Interference-mitigating effects of AAs	150
D.3.1	Inbound SS-to-BS interference with AA at the BS.....	150
D.3.1.1	Simulation model	150
D.3.1.2	Simulation results and discussion	151

LIST OF FIGURES

Figure 1—Reference diagram for FBWA systems	9
Figure 2—Forms of interference	10
Figure 3—Interference sources to a FBWA BS	11
Figure 4—Simplified model for interference to a FBWA BS	13
Figure 5—Interference sources to a FBWA SS	14
Figure 6—Interference sources to omnidirectional mesh system (BS and SS)	15
Figure 7—Systems for channel separation (CS) $1 < CS \leq 10$ MHz	24
Figure 8—Systems for CS > 10 MHz	25
Figure 9—Availability versus C/I for a fixed cell radius for $R = 3.6$ km	26
Figure 10—Radius versus C/I for a fixed availability of 99.995%	27
Figure 11—Geometry of radio horizon	29
Figure 12—Composite co-polarized RPE for 1 ft HP 38 GHz antenna	46
Figure 13—Composite cross-polarized RPE for 1 ft HP 38 GHz antenna	46
Figure 14—Comparison of co-polarized composite of HP 1 ft 38 GHz antennas	47
Figure 15—Comparison of cross-polarized composite of HP 1 ft 38 GHz antennas	48
Figure 16—Comparison of co-polarized composite of HP 2 ft 38 GHz antennas	49
Figure 17—Comparison of cross-polarized composite of HP 2 ft 38 GHz antennas	50
Figure 18—Comparison of co-polarized composite of HP 1 ft 25 GHz antennas	51
Figure 19—Comparison of cross-polarized composite of HP 1 ft 25 GHz antennas	52
Figure 20—Comparison of co-polarized composite of HP 2 ft 25 GHz antennas	53
Figure 21—Comparison of cross-polarized composite of HP 2 ft 25 GHz antennas	54
Figure 22—One interpretation of Table 17 results for no guard channel	58
Figure 23—Impact of the results displayed in Table 18 and Table 19	61
Figure 24—Cumulative probability distributions	68
Figure 25—Illustration of psfd computation height at service area boundary	77
Figure 26—Example mesh scenario using minimized energy-per-bit routing	82
Figure 27—Example mesh scenario using min. hopcount, max. modulation routing	83
Figure 28—Interference cdf for nearest co-channel node	83
Figure 29—Interference cdf for nearest adj. channel node	84
Figure B.1—Band edge definitions	93
Figure B.2—Simulation model for SS to BS	97
Figure B.3—Simulation model for BS to SS	99
Figure B.4—Layout model	100
Figure B.5—Victim BS	101
Figure B.6—Worst-case interference	102
Figure B.7—SS to SS, same area, AdjCh, TDD only	103
Figure B.8—Path geometry for SS-to-BS CoCh simulation (FDD and TDD)	104
Figure B.9—Simulation geometry	105
Figure B.10—Mesh-to-PMP-BS, CoCh, adjacent area	106
Figure B.11—Tx masks based on -70 dBc floor and spectrum masks from [B8]	110
Figure B.12—Example NFD plot	121
Figure C.1—Interference geometry (PMP BS to PTP link)	124
Figure C.2—Interference geometry (PMP SS to PTP link station)	124
Figure C.3—Interference geometry (PTP link to PMP BS)	125
Figure C.4—Interference geometry (PTP link station to PMP SS)	126
Figure C.5—Interference plotted as cumulative probability curves as function of R	128
Figure C.6—Interference geometry	130
Figure C.7—Example of cumulative probability distributions (BS interference)	131
Figure C.8—Interference geometry (PMP BS to PTP link)	132
Figure C.9—Interference power profile from PTP to PMP BS (1 guard channel)	134
Figure C.10—Interference power profile from PTP to PMP SS (1 guard channel)	135

Figure D.1—Boundary BS-to-SS interference geometry	142
Figure D.2—Boundary BS-to-BS interference geometry.....	143
Figure D.3—Boundary SS-to-SS interference geometry	144
Figure D.4—Illustrative multiple operator frequency assignments.....	145
Figure D.5—Generic same-area simulation model	145
Figure D.6—Rain attenuation model.....	146
Figure D.7— AA simulation geometry	150

LIST OF TABLES

Table 1—Summary of the guidelines for geographical and frequency spacing.....	20
Table 2—Comparison of typical regulatory EIRP limits and simulation assumptions.....	21
Table 3—Maximum psfd limits.....	29
Table 4—Horizon range for different radio heights above ground level (in km).....	30
Table 5—Summary of the simulations and calculations.....	33
Table 6—Dominant interference mechanisms between FBWA and PTP systems.....	42
Table 7—Characteristics of system with multiple PTP links.....	43
Table 8—Characteristics of PTP link.....	44
Table 9—Breakpoints of co-polarized composite of HP 1 ft 38 GHz antennas.....	47
Table 10—Breakpoints of cross-polarized composite of HP 1 ft 38 GHz antennas.....	48
Table 11—Breakpoints of co-polarized composite of HP 2 ft 38 GHz antennas.....	49
Table 12—Breakpoints of cross-polarized composite of HP 2 ft 38 GHz antennas.....	50
Table 13—Breakpoints of co-polarized composite of HP 1 ft 25 GHz antennas.....	51
Table 14—Breakpoints of cross-polarized composite of HP 1 ft 25 GHz antennas.....	52
Table 15—Breakpoints of co-polarized composite of HP 2 ft 25 GHz antennas.....	53
Table 16—Breakpoints of cross-polarized composite of HP 2 ft 25 GHz antennas.....	54
Table 17—Class B1, sample PMP-BS-to-PTP separation distances (km).....	57
Table 18—Class B3, NFD=27 dB (i.e., AdjCh), sample C/I at Rx of PMP SS.....	59
Table 19—Class B3, NFD=50 dB (i.e., 1 guard channel), sample C/I at PTP Rx of PMP SS.....	60
Table 20—Summary of simulations and calculations.....	63
Table 21—Summary of the guidelines for geographical and frequency spacing.....	72
Table 22—Parameters for 3.5 GHz systems with a PMP architecture.....	73
Table 23—Parameters for 3.5 GHz mesh deployments.....	74
Table 24—Parameters for 10.5 GHz systems with a cellular architecture.....	75
Table 25—Maximum psfd limits.....	77
Table 26—Summary of the simulations and calculations.....	80
Table B.1—Minimum separation between actual and virtual band edge for different bands.....	92
Table B.2—Simulation results.....	111
Table B.3—Interference classes.....	112
Table B.4—Proposed psfd levels in the 24 GHz, 28 GHz, and 38 GHz bands.....	114
Table B.5—Simulation parameter values.....	118
Table B.6—Separation distances/frequency spacing against NFD values.....	121
Table C.1—Summary of results.....	125
Table C.2—Summary of results.....	126
Table C.3—Summary of results.....	129
Table C.4—Summary of BS interference scenarios using new antenna RPE.....	131
Table C.5—Summary of SS interference scenarios.....	132
Table C.6—Parameters for PMP to PTP interference scenarios.....	133
Table D.1—Representative system and equipment parameters.....	137
Table D.2—Spherical earth diffraction loss at 3.5 GHz ($D_i = 30$ km).....	138
Table D.3—Spherical earth diffraction loss at 10.5 GHz ($D_i = 30$ km).....	139
Table D.4—Spherical earth diffraction loss at 3.5 GHz ($D_i = 60$ km).....	139
Table D.5—Spherical earth diffraction loss at 3.5 GHz ($D_i = 70$ km).....	139
Table D.6—Spherical earth diffraction loss at 3.5 GHz ($D_i = 80$ km).....	140
Table D.7—Spherical earth diffraction loss at 10.5 GHz ($D_i = 60$ km).....	140
Table D.8—Spherical earth diffraction loss at 10.5 GHz ($D_i = 70$ km).....	140
Table D.9—Spherical earth diffraction loss at 10.5 GHz ($D_i = 80$ km).....	141

Coexistence of Fixed Broadband Wireless Access Systems

1. Overview

This recommended practice provides recommendations for the design and coordinated deployment of fixed broadband wireless access (FBWA) systems in order to control interference and facilitate coexistence among these systems and with other applicable systems that may be present.

Due to the distinctly different physical behavior over the frequency range to which this recommended practice is applicable, this document addresses several such frequency subranges separately. Specifically, the following topics are addressed:

- Coexistence among FBWA systems operating in 23.5–43.5 GHz frequencies
- Coexistence of FBWA systems with point-to-point (PTP) systems operating in 23.5–43.5 GHz frequencies
- Coexistence among FBWA systems operating in 2–11 GHz licensed bands

For each of the above topics, the following aspects are addressed:

- Summary of applicable coexistence recommendations and guidelines.
- Overview of the systems for which coexistence criteria are analyzed, including system architecture and medium overview.
- Equipment design parameters relevant to the analyses.
- Methodology to be used in the deployment and coordination of systems.
- Interference and propagation evaluation examples, indicating some of the models, simulations, and analyses used in the preparation of this recommended practice.
- Possible mitigation techniques in case of co-channel (CoCh) interference between systems operating in adjacent areas or in case of undesired signals caused by natural phenomena and other unintentional sources.

The intent of this recommended practice is to define a set of consistent design and deployment recommendations that promote coexistence for FBWA systems and for PTP systems that share the same bands. The recommendations have been developed and substantiated by analyses and simulations specific to

the deployment and propagation environment appropriate to terrestrial FBWA intersystem interference experienced between operators licensed for FBWA and operators of PTP link systems sharing the same bands. These recommendations, if followed by manufacturers and operators, will facilitate a wide range of equipment to coexist in a shared environment with acceptable mutual interference.

Radio waves permeate through legislated (and even national) boundaries, and emissions spill outside spectrum allocations. Coexistence issues between multiple operators are, therefore, inevitable. The resolution of coexistence issues is an important factor for the FBWA industry. The recommendations in 5.2, 6.1, and 7.2 are provided for consideration by operators, manufacturers, and administrations to promote coexistence. Practical implementation within the scope of the current recommendations will assume that some portion of the frequency spectrum (at the edge of the authorized bandwidth) may be unusable. Furthermore, some locations within the service area may not be usable for deployment. Coexistence will rely heavily on the good-faith collaboration between spectrum holders to find and implement economical solutions.

This recommended practice is not intended to be a replacement for applicable regulations, which would take precedence.

1.1 Scope

This recommended practice revises IEEE Std 802.16.2TM-2001. In particular, it specifies extensions and modifications addressing two distinct topics. The first is coexistence between multipoint (MP) systems and PTP systems in the 10–66 GHz frequency range. The second is coexistence among FBWA systems operating in licensed bands within the 2–11 GHz frequency range. Updates to the existing content are also considered.

1.2 Purpose

The purpose of this recommended practice is to provide coexistence guidelines to license holders, service providers, deployment groups, and system integrators. The specifications will facilitate the deployment and operation of FBWA systems while minimizing the need for case-by-case coordination.

2. Normative references

This recommended practice shall be used in conjunction with the following:

ETSI EN 301 390 (2003-11), Fixed Radio Systems; Point-to-point and Point-to-Multipoint Systems; Spurious emissions and receiver immunity at equipment/antenna port of Digital Fixed Radio Systems.¹

ITU-R Recommendation F.1509 (02/01): Technical and operational requirements that facilitate sharing between point-to-multipoint systems in the fixed service and the inter-satellite service in the band 25.25–27.5 GHz.²

¹ETSI standards are available from publication@etsi.fr and <http://www.etsi.org/eds/eds.htm>.

²ITU-R publications are available from the International Telecommunications Union, Place des Nations, CH-1211, Geneva 20, Switzerland/Suisse (<http://www.itu.int>).

3. Definitions and Abbreviations

For the purposes of this recommended practice, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B30]³, should be referenced for terms not defined in this clause.

Other standards (e.g., ITU-R Recommendation F.1399-1 (2001-05) [B37]) employ comparable definitions and abbreviations to those that follow. However, while comparable, they differ in a number of cases.

3.1 Definitions

3.1.1 authorized band: The frequency range(s) over which an operator is permitted to operate radio transmitters and receivers.

3.1.2 automatic transmit power control (ATPC): A technique used in broadband wireless access (BWA) systems to adaptively adjust the power of a transmitter to maintain the received signal level within some desired range.

3.1.3 base station (BS): A generalized equipment set providing connectivity, management, and control of the subscriber stations (SSs).

3.1.4 block bandwidth (B): The contiguous authorized bandwidth available to an operator.

3.1.5 broadband: Having instantaneous bandwidths greater than 1 MHz and supporting data rates greater than about 1.5 Mbit/s.

3.1.6 broadband wireless access (BWA): Wireless connectivity in which the connection(s) capabilities are broadband.

3.1.7 channel bandwidth: For single carriers, the bandwidth assigned to individual carriers within a block. This may differ for different carriers within a block. The occupied bandwidth of a carrier within a channel may be less than or equal to the bandwidth of a channel. For a multicarrier transmission using a common amplifier stage, the sum of all composite carriers.

3.1.8 cross-polar discrimination (XPD): For a given direction, the difference in decibels between the peak co-polarized gain of the antenna and the cross-polarized gain of the antenna.

3.1.9 dBi: In the expression of antenna gain, the number of decibels of gain of an antenna referenced to the 0 dB gain of a free-space isotropic radiator.

3.1.10 digital modulation: The process of varying one or more parameters of a carrier wave (e.g., frequency, phase, amplitude, or combinations thereof) as a function of two or more finite and discrete states of a signal.

3.1.11 downlink: The direction from a base station (BS) to the subscriber station (SS).

3.1.12 DS-3: A North American Common Carrier Multiplex level having a line rate of 44.736 Mbit/s.

3.1.13 fixed wireless access: Wireless access application in which the location of the subscriber station (SS) and the base station (BS) are fixed in location.

³The numbers in brackets correspond to the numbers of the bibliography in Annex A.

3.1.14 frequency block: A contiguous portion of spectrum within a subband or frequency band, typically assigned to a single operator. A collection of frequency blocks may form a subband and/or a frequency band.

3.1.15 frequency division duplex (FDD): A duplex scheme in which uplink and downlink transmissions use different frequencies but are typically simultaneous.

3.1.16 frequency reuse: A technique for employing a set of frequencies in multiple, closely spaced cells and/or sectors for the purpose of increasing network traffic capacity.

3.1.17 guard band: Spectrum identified between adjacent operator frequency blocks, specifically for providing some isolation between the systems deployed in these neighboring frequencies.

3.1.18 harmonized transmissions: The use, by multiple operators, of a compatible transmission plan so that the base stations (BSs) from different operators can share an antenna site and minimize interference. For frequency division duplex (FDD) systems, this implies that each operator's BS transmits in the same frequency subblock (typically on a different channel) and that each terminal transmits in the corresponding paired subblock. For time-division duplex (TDD) systems, harmonization implies frame, slot, and uplink/downlink synchronization.

3.1.19 intercell link: A radio link used to interconnect two or more base station (BS) sites.

3.1.20 line of sight (LOS): Condition in which the signal path is >60% clear of obstructions within the first Fresnel Zone.

3.1.21 mesh: A wireless network topology, also known as multipoint-to-multipoint (MP-MP), in which a number of subscriber stations (SSs) within a geographic area are interconnected and can act as repeater stations (RSs). This allows a variety of routes between the core network and any SS. Mesh systems do not have base stations (BSs) in the conventional point-to-multipoint (PMP) sense.

3.1.22 multicarrier system: A system using two or more carriers to provide service from a single transmitter.

3.1.23 multipoint (MP): A generic term for point-to-multipoint (PMP), multipoint-to-multipoint (MP-MP), and variations or hybrids of these. MP is a wireless topology in which a system provides service to multiple, geographically distributed, subscriber stations (SSs). The sharing of resources may occur in the time domain, frequency domain, or both.

3.1.24 multipoint-to-multipoint (MP-MP): See **mesh**.

3.1.25 narrowband: Operating with a bit rate not exceeding 64 kbit/s.

3.1.26 net filter discrimination (NFD): The ratio between the power transmitted by the interfering system and the portion that could be measured after the receiving filter of the useful system.

3.1.27 non line of sight (NLOS): Condition in which the signal path is <40% clear of obstructions within the first Fresnel Zone.

3.1.28 OC-3: One hierarchical level in the Synchronous Optical Network transmission standard. The line rate for this level is 155.52 Mbit/s.

3.1.29 occupied bandwidth (B_O): For a single carrier, B_O is the width of a frequency band such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5% of the total mean power radiated by a given emission. This implies that 99% of the total mean emitted power is within this band, and hence this bandwidth is also known as the 99% bandwidth.

When a multicarrier transmission uses a common amplifier stage, the occupied bandwidth of this composite transmission is defined by the following relationship:

$$B_{OM} = 1/2 B_{OU} + 1/2 B_{OL} + (F_{0U} - F_{0L})$$

where

B_{OM} = occupied bandwidth of the multicarrier system,

B_{OU} = single-carrier occupied bandwidth of the uppermost subcarrier,

B_{OL} = single-carrier occupied bandwidth of the lowermost subcarrier,

F_{0U} = center frequency of the uppermost subcarrier,

F_{0L} = center frequency of the lowermost subcarrier.

NOTE—This multicarrier definition will give a bandwidth that is slightly wider than the multicarrier 99% power bandwidth. For example, for six identical, adjacent carriers, B_O will contain 99.5% of the first carrier, 99.5% of the last carrier and 100% of the four middle carriers and, therefore, 99.8333% of total mean power.

3.1.30 out-of-block (OOB) emissions: Emissions from the edge of the authorized bandwidth up to 200% of the occupied bandwidth from the edge of the authorized bandwidth. These emissions occur both above and below the authorized bandwidth.

3.1.31 point-to-multipoint (PMP): In wireless systems, a topology where a base station (BS) services multiple, geographically separated subscriber stations (SSs), and each SS is permanently associated with only one BS.

3.1.32 point-to-point (PTP): A topology in which a dedicated radio link is maintained between two stations.

3.1.33 power flux density (pfd): The radiated power flux per unit area.

3.1.34 power spectral flux density (psfd): The radiated power flux per unit bandwidth per unit area.

3.1.35 radiation pattern envelope (RPE): RPE is an agreed mask defining an upper bound that antenna radiation patterns are expected to fit beneath. The RPE is usually presented as a plot or a table, representing a function of relative radiation power density versus angular offset in a defined plane with respect to an axis along the antenna direction exhibiting maximum radiation (antenna boresight). The radiation power density is usually expressed in dB relative to the maximum radiation power density on antenna boresight in the primary polarization orientation. The RPE is usually applicable over a defined frequency range for the antennas under consideration.

3.1.36 repeater station (RS): A station other than the base station (BS) that includes radio communication equipment facing two or more separate directions. Traffic received from one direction may be partly or wholly retransmitted in another direction. Traffic may also terminate and originate at the RS.

3.1.37 second adjacent channel (AdjCh): Next channel beyond the AdjCh.

3.1.38 service area: A geographic area in which an operator is authorized to transmit.

3.1.39 spectrum disaggregation: Segregation of spectrum to permit several operators access to subportions of a licensee's authorized band.

3.1.40 spurious emissions: Emissions greater than 200% of the occupied bandwidth from the edge of the authorized bandwidth.

NOTE—This definition is adopted for use in this recommended practice. For a more general definition, see ITU Radio Regulations [B33].

3.1.41 subscriber station (SS): A generalized equipment set providing connectivity between subscriber equipment and a base station (BS).

3.1.42 synchronized transmissions: Harmonized time-division duplex (TDD) transmissions.

3.1.43 terminal equipment (TE): A wide variety of apparatus at customer premises, providing end user services and connecting to subscriber station (SS) equipment via one or more interfaces.

3.1.44 time-division duplex (TDD): A duplex scheme where uplink and downlink transmissions occur at different times but may share the same frequency.

3.1.45 uplink: The direction from a subscriber station (SS) to the base station (BS).

3.1.46 unwanted emissions: Out-of-band emissions, spurious emissions, and harmonics.

3.1.47 virtual block edge: A reference frequency used as a block edge frequency for testing of unwanted emissions to avoid effects of radio frequency (RF) block filters.

3.1.48 wireless access: End-user radio connection(s) to core networks.

3.1.49 %KO: Percentage area of a point-to-multipoint (PMP) cell area where interference may afflict or arise from subscriber station (SS) and “knock out” the radio receiver(s).

3.2 Abbreviations

AA	adaptive antenna
AdjCh	adjacent channel
ATPC	automatic transmit power control
AZ	azimuth
BER	bit error ratio
B _O	occupied bandwidth
BS	base station
BW	bandwidth
BWA	broadband wireless access
CDF	cumulative distribution function
CDMA	code division multiple access
<i>C/I</i>	carrier-to-interference ratio
<i>C/N</i>	carrier-to-noise ratio
<i>C/(N + I)</i>	carrier-to-(noise and interference) ratio
CoCh	co-channel
Co-Pol	co-polar
CS	channel separation
CW	continuous wave
dBc	decibels relative to the carrier level
dB _i	see 3.1.9
DRS	data relay satellite
DS-3	44.736 Mbit/s line rate
<i>D/U</i>	desired-carrier-to-undesired-carrier ratio
EL	elevation
EIRP	equivalent isotropically radiated power

FBWA	fixed broadband wireless access
FDD	frequency division duplex
FDMA	frequency division multiple access
FSPL	free space path loss
GSO	geostationary orbit
HP	high performance
IA	interference area
ICL	interference coupling loss
I/N	interference-to-thermal-noise ratio
ISOP	interference scenario occurrence probability
LMCS	local multipoint communication system
LMDS	local multipoint distribution service
LOS	line of sight
MAN	metropolitan area network
MCL	minimum coupling loss
MMDS	multichannel multipoint distribution system
MP	multipoint
MP-MP	multipoint-to-multipoint
MWS	multimedia wireless systems
NFD	net filter discrimination
NLOS	non line of sight
OC-3	155.52 Mbit/s line rate
OFDM	orthogonal frequency division multiplexing
OFDMA	orthogonal frequency division multiple access
OOB	out-of-block
PCS	personal communication service
pfd	power flux density
PMP	point-to-multipoint
psd	power spectral density
psfd	power spectral flux density
PTP	point-to-point
QAM	quadrature amplitude modulation
QPSK	quadrature phase shift keying
RF	radio frequency
RPE	radiation pattern envelope
RS	repeater station
RSS	Radio Standards Specifications
Rx	receive
SRSP	Standard Radio Systems Plan
SS	subscriber station
TDD	time division duplex
TDMA	time division multiple access
TE	terminal equipment
Tx	transmit
XPD	cross-polar discrimination
X-Pol	cross-polar

4. System overview

Broadband wireless access (BWA) generally refers to fixed radio systems used primarily to convey broadband services between users' premises and core networks. The term *broadband* is usually taken to mean the capability to deliver significant bandwidth to each user. In ITU terminology, and in this

recommended practice, broadband transmission generally refers to transmission rate of greater than 1.5 Mbit/s, though many BWA networks support significantly higher data rates.

The networks operate transparently, so users are not aware that services are delivered by radio. A typical FBWA network supports connection to many user premises within a radio coverage area. It provides a pool of bandwidth, shared automatically among the users. Demand from different users is often statistically of low correlation, allowing the network to deliver significant bandwidth-on-demand to many users with a high level of spectrum efficiency. Significant frequency reuse is employed.

The range of applications is very wide and evolving quickly. It includes voice, data, and entertainment services of many kinds. Each subscriber (i.e., customer) may require a different mix of services; this mix is likely to change rapidly as connections are established and terminated. Traffic flow may be unidirectional, asymmetrical, or symmetrical, again changing with time. In some territories, systems delivering these services are referred to as multimedia wireless systems (MWS) in order to reflect the convergence between traditional telecommunications services and entertainment services.

These radio systems compete with other wired and wireless delivery means for the first-mile connection to services. Use of radio or wireless techniques results in a number of benefits, including rapid deployment and relatively low up-front costs.

4.1 System architecture

FBWA systems often employ MP architectures. MP includes point-to-multipoint (PMP) and mesh. The IEEE 802.16 Working Group on Broadband Wireless Access has developed a standard (IEEE Std 802.16TM-2001 [B31], IEEE Std 802.16cTM-2002 [B32], and IEEE Std 802.16aTM-2003 [B87]) containing a fully specified air interface for PMP (2–66 GHz) and mesh (2–11 GHz) systems. Similar standards have been developed within the HIPERACCESS and HIPERMAN working groups of the ETSI Broadband Radio Access Networks Project. In addition, a number of proprietary FBWA systems exist for which the air interface is not standardized.

FBWA systems typically include base stations (BSs), subscriber stations (SSs), terminal equipment (TE), core network equipment, intercell links, repeater stations (RSs), and possibly other equipment. A reference FBWA system diagram is provided in Figure 1. This diagram indicates the relationship between various components of a BWA system. BWA systems may be much simpler and contain only some elements of the network shown in Figure 1. A FBWA system contains at least one BS and a number of SS units. In Figure 1, the wireless links are shown as zigzag lines connecting system elements.

Intercell links may use wireless, fiber, or copper facilities to interconnect two or more BS units. Intercell links may, in some cases, use in-band PTP radios that provide a wireless backhaul capability between BSs at rates ranging from DS-3 to OC-3. Such PTP links may operate under the auspices of the PMP license.

Some systems deploy RSs. In a PMP system, RSs are generally used to improve coverage to locations where the BS(s) have no line of sight (LOS) within their normal coverage area(s), or alternatively to extend coverage of a particular BS beyond its normal transmission range. A repeater station (RS) relays information from a BS to one or a group of SSs. It may also provide a connection for a local SS. A repeater station may operate on the same downlink frequencies as the frequencies that it uses, facing the BS, or it may use different frequencies (i.e., demodulate and remodulate the traffic on different channels). In MP-MP systems, most stations are RSs that also provide connections for local subscribers.

The boundary of the FBWA network is at the interface points F and G of Figure 1. The F interfaces are points of connection to core networks and are generally standardized. The G interfaces, between SSs and terminal equipment, may be either standardized or proprietary.

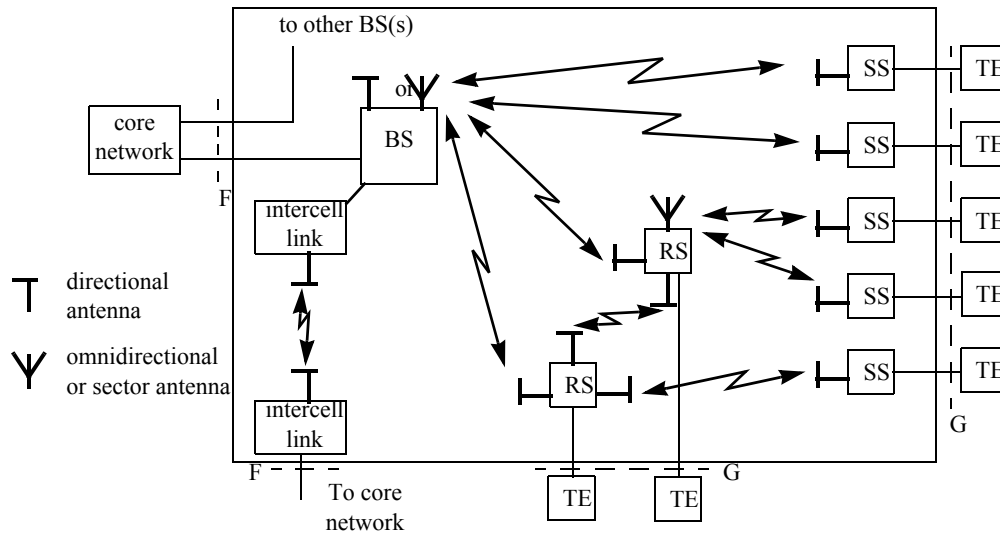


Figure 1—Reference diagram for FBWA systems

4.1.1 PMP systems

PMP systems comprise BSs, SSs and, in some cases, RSs. BSs use relatively wide beam antennas, divided into one or several sectors providing up to 360° coverage with one or more antennas. To achieve complete coverage of an area, more than one BS may be required. The connection between BSs is not part of the FBWA network itself, being achieved by use of radio links, fiber optic cable, or equivalent means.

Links between BSs may sometimes use part of the same frequency allocation as the FBWA itself. Routing to the appropriate BS is a function of the core network. SSs use directional antennas, facing a BS and sharing use of the radio channel. This may be achieved by various access methods, including (orthogonal) frequency division, time division, or code division.

4.1.2 Mesh systems

Mesh systems have the same functionality as PMP systems. BSs provide connections to core networks on one side and radio connection to other stations on the other. A SS may be a radio terminal or (more typically) a RS with local traffic access. Traffic may pass via one or more RSs to reach a SS.

4.1.3 Antenna subsystems

The antenna subsystems employed generally depend on the frequency band in use and the system type.

For microwave PMP SSs, the antenna subsystem is generally very highly directive, as LOS is typically required. Microwave mesh SSs typically employ multiple antennas of this type and employ a means for remote alignment.

For millimeter wave BSs, adaptive antenna (AA) systems may be employed to improve performance. For millimeter wave PMP SSs, the antenna subsystem is generally highly directive, though typically less so than for microwave PMP SSs to enable near-LOS and/or non-LOS (NLOS) operation to some extent. Millimeter wave mesh SSs typically use omnidirectional antennas.

4.2 Interference scenarios

4.2.1 Forms of interference

Interference can be classified into two broad categories: CoCh interference and out-of-channel interference. These manifest themselves as shown in Figure 2.

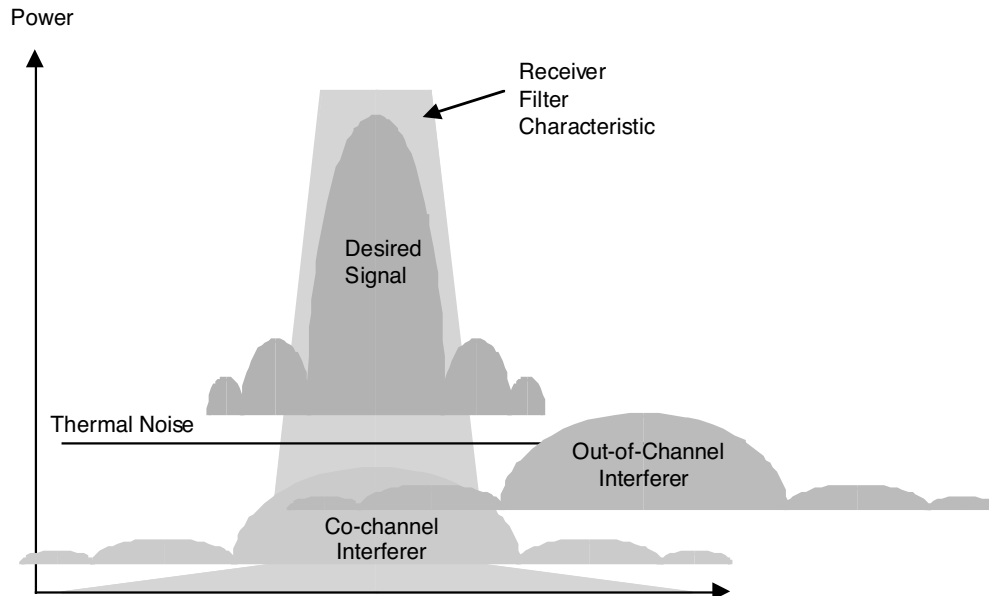


Figure 2—Forms of interference

Figure 2 illustrates the power spectrum of the desired signal and CoCh interference in a simplified example. Note that the channel bandwidth of the CoCh interferer may be wider or narrower than the desired signal. In the case of a wider CoCh interferer (as shown), only a portion of its power will fall within the receiver filter bandwidth. In this case, the interference can be estimated by calculating the power arriving at the receive (Rx) antenna and then multiplying by a factor equal to the ratio of the filter's bandwidth to the interferer's bandwidth.

An out-of-channel interferer is also shown. Here, two sets of parameters determine the total level of interference as follows:

- A portion of the interferer's spectral sidelobes or transmitter output noise floor falls CoCh to the desired signal; i.e., within the receiver filter's passband. This can be treated as CoCh interference. It cannot be removed at the receiver; its level is determined at the interfering transmitter. By characterizing the power spectral density (psd) of sidelobes and output noise floor with respect to the main lobe of a signal, this form of interference can be approximately computed in a manner similar to the CoCh interference calculation, with an additional attenuation factor due to the suppression of this spectral energy with respect to the main lobe of the interfering signal.
- The main lobe of the interferer is not completely suppressed by the receiver filter of the victim receiver. No filter is ideal; and residual power, passing through the stopband of the filter, can be treated as additive to the CoCh interference present. The level of this form of interference is determined by the performance of the victim receiver in rejecting out-of-channel signals, sometimes referred to as *blocking performance*. This form of interference can be simply estimated in a manner similar to the CoCh interference calculation, with an additional attenuation factor due to the relative rejection of the filter's stopband at the frequency of the interfering signal.

Quantitative input on equipment parameters is required to determine which of the two forms of interference from an out-of-channel interferer will dominate.

4.2.2 Acceptable level of interference

A fundamental property of any FBWA system is its link budget, in which the range of the system is computed for a given availability, with given rain fading. During the designed worst-case rain fade, the level of the desired received signal will fall until it just equals the receiver thermal noise, $kTBF$, (where k is Boltzmann's constant, T is the temperature, B is the receiver bandwidth, and F is the receiver noise), plus the specified signal-to-noise ratio of the receiver. A way to account for interference is to determine $C/(N + I)$, the ratio of carrier level to the sum of noise and interference. For example, consider a receiver with 6 dB noise figure. The receiver thermal noise is -138 dBW in 1 MHz. Interference of -138 dBW in 1 MHz would double the total noise, or degrade the link budget by 3 dB. Interference of -144 dBW in 1 MHz, 6 dB below the receiver thermal noise, would increase the total noise by 1 dB to -137 dBW in 1 MHz, degrading the link budget by 1 dB.

For a given receiver noise figure and antenna gain in a given direction, the link budget degradation can be related to a received power flux density (pfd) tolerance. In turn, this tolerance can be turned into separation distances for various scenarios.

4.2.3 Interference paths

4.2.3.1 Victim BS

Figure 3 shows main sources of interference where the victim receiver is a FBWA BS, with a sectoral-coverage antenna.

The victim BS is shown as a black triangle on the left, with its radiation pattern represented as ellipses. The desired SS transmitter is shown on lower right of figure. In the worst case, the desired signal travels through a localized rain cell, and is received at minimum signal strength. Thus, interference levels close to the thermal noise floor are significant.

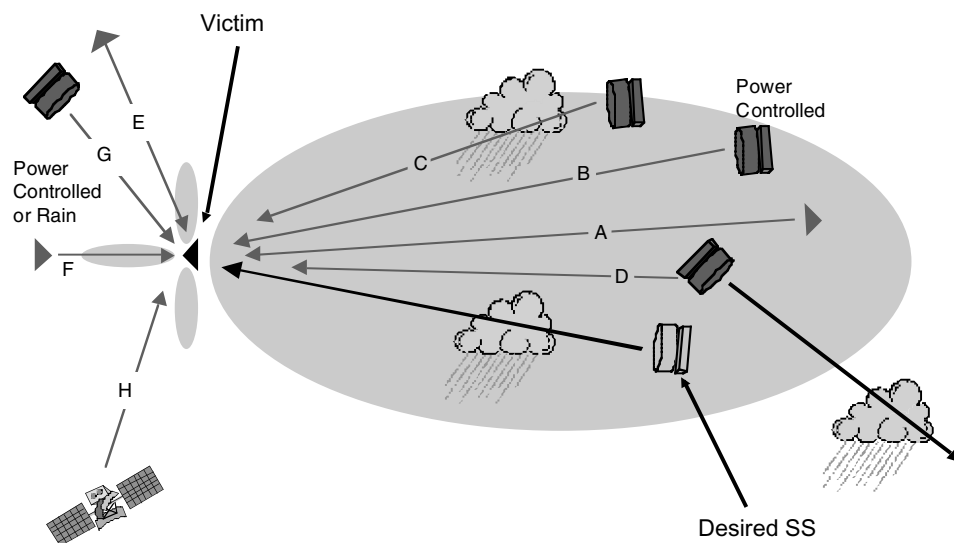


Figure 3—Interference sources to a FBWA BS

The letters in Figure 3 illustrate several cases of interference to a BS.

Case A shows BS-to-BS interference in which each BS antenna is in the main beam of the other. This case could occur commonly, as sector coverage angles tend to be wide—up to 90° . In fact, a victim BS could tend to see the aggregate power of several BSs. In addition, BS antennas tend to be elevated, with a high probability of an LOS path to each other. As rain cells can be very localized, it is quite conceivable that the interferer travels on a path relatively unattenuated by rain, while the desired signal is heavily attenuated. BS-to-BS interference can be reduced by ensuring that there is no CoCh BS transmission on frequencies being used for reception at other BSs. This is possible with frequency division duplex (FDD) through cooperative band planning, where vendors agree to use a common subband for BS transmissions and another common subband for BS reception.

Case B shows SS-to-BS interference in which each antenna is in the main beam of the other. As SS antenna gain is much higher than the BS antenna gain, this might appear to be the worst possible case. However, FBWA PMP systems can safely be assumed to employ uplink adaptive power control at SSs. (Power control is required to equalize the received signal strength arriving at a BS from near and far SSs on adjacent channels (AdjChs). Note that active control of downlink power from BS transmitters is usually not employed, as the BS signal is received by a variety of SSs, both near and far, and power control would tend to create an imbalance in the level of signals seen from adjacent sectors.) Assuming that the SS in Case B sees clear air, it can be assumed to have turned its power down, roughly in proportion to the degree of fade margin of its link. Note, however, that power control is imperfect, so the degree of turndown may be less than the fade margin. The turndown compensates for the fact that the SS antenna has such high gain, so the net effect is that Case B may not be more severe than Case A. In addition, the narrow beamwidth of a SS antenna ensures that Case B is much less common an occurrence than Case A. However, Case B interference cannot be eliminated by band planning. Case B also covers interference generated by terrestrial PTP transmitters.

Case C is similar to Case B, except the interferer is assumed to see a rain cell and, therefore, does not turn down its power. However, as the interferer's beamwidth is narrow, the interference must also travel through this rain cell on the way to the victim receiver; hence, the net result is roughly the same as Case B. Because power control tracks out the effect of rain, interference analysis can be simplified: we need to consider either Case B or Case C, but not both. Thus Case B is more conservative with imperfect power control; i.e., the turndown will tend to be less than the fade margin, so the net received power at the victim receiver is several decibels higher than in Case C.

Case D is similar to Case C, except the interference is stray radiation from a sidelobe or backlobe of the SS antenna. In the worst case, the SS antenna sees rain towards its intended receiver and, therefore, does not turn down its power. Modeling of this case requires assumptions of the sidelobe and backlobe suppression of typical SS antennas. These assumptions need to take into account scattering from obstacles in the main lobe path appearing as sidelobe emissions in real-world installations of SS antennas; an antenna pattern measured in a chamber is one thing while the effective pattern installed on a rooftop is another. If effective sidelobe and backlobe suppression exceeds the power turndown assumption for clear skies, then Case B dominates and Case D need not be considered. The only exception is where Case D models a source of interference that is not a FBWA system but a PTP transmitter or a satellite uplink. In these cases, the transmit parameters may be so different from a FBWA SS that the interference could be significant.

Case E is another case of BS-to-BS interference. In this case, the interfering BS's main beam is in the victim's sidelobe or backlobe. In a related scenario (not shown), the interfering BS's sidelobe is in the victim's main lobe. As FBWA systems tend to employ intensive frequency reuse, it is likely that Case A concerns will dominate over Case E.

Case F covers BS-to-BS backlobe-to-backlobe or sidelobe-to-sidelobe interference. The low gains involved here ensure that this is a problem only for co-deployment of systems on the same rooftop. Like all sources of BS-to-BS interference, this can be virtually eliminated in FDD via a coordinated band plan.

Case G covers interference from an SS antenna to the victim BS's sidelobe or backlobe. Referring to the commentary concerning Cases B and C, only the clear air case need be considered, and an assumption can be made that the interferer has turned down its power. As BS antennas see wide fields of view, Case B is expected to dominate and Case G need not be considered.

Finally, **Case H** covers interference from a satellite downlink or stratospheric downlink. This case is not included in this recommended practice. With the above simplifying assumptions, the interference to be considered here are illustrated in Figure 4.

Case A will tend to dominate unless there is a harmonized band plan for the use of FDD. It will be of concern for unsynchronized time-division duplex (TDD) or unharmonized FDD. Case B is always a concern. Case D is probably of less concern than Case B when the interferer is a FBWA system, but could be significant if the interferer is a higher-power PTP transmitter or satellite uplink. Case F is a concern only for co-sited BSs and can be largely mitigated by the use of a harmonized band plan with FDD.

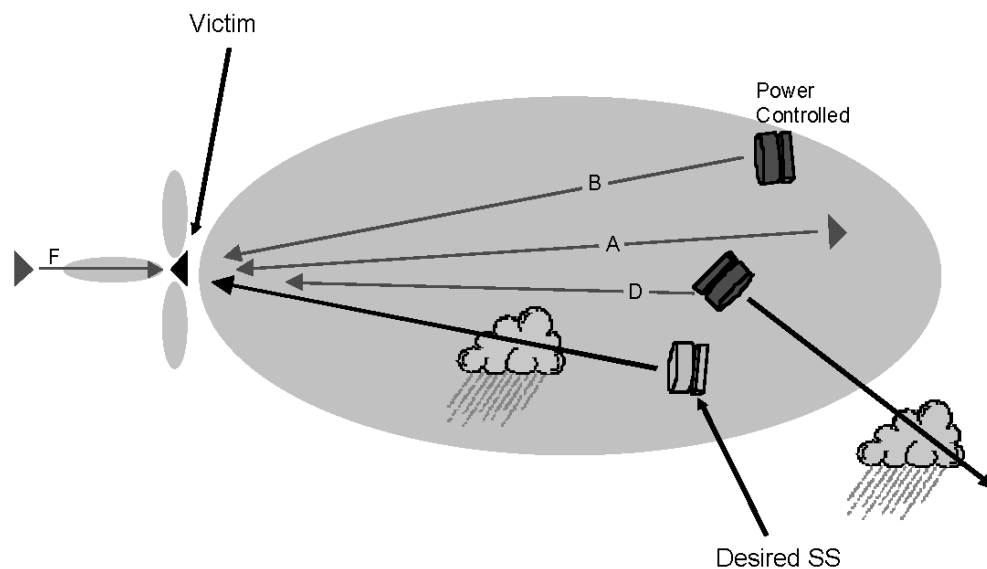


Figure 4—Simplified model for interference to a FBWA BS

4.2.3.2 Victim SS

Figure 5 shows the main sources of interference to a SS having a narrow beamwidth antenna.

The victim SS is shown along with its radiation pattern (ellipses). The BS and several interferers are also shown. The victim SS cases are fundamentally different from the victim BS cases because the antenna pattern is very narrow. If the desired signal is assumed to be attenuated due to a rain cell, then interference arriving in the main lobe must also be assumed to be attenuated. The letters in Figure 5 illustrate several cases of interference to a SS:

Case A covers SS-to-SS interference where the beams are colinear (which is relatively rare). In these cases, the interferer is generally far away from the victim; therefore, it may be assumed that the rain cell attenuating the interference as it arrives at the victim is not in the path from the interferer to its own BS. In this case, the interferer sees clear air and turns down its power.

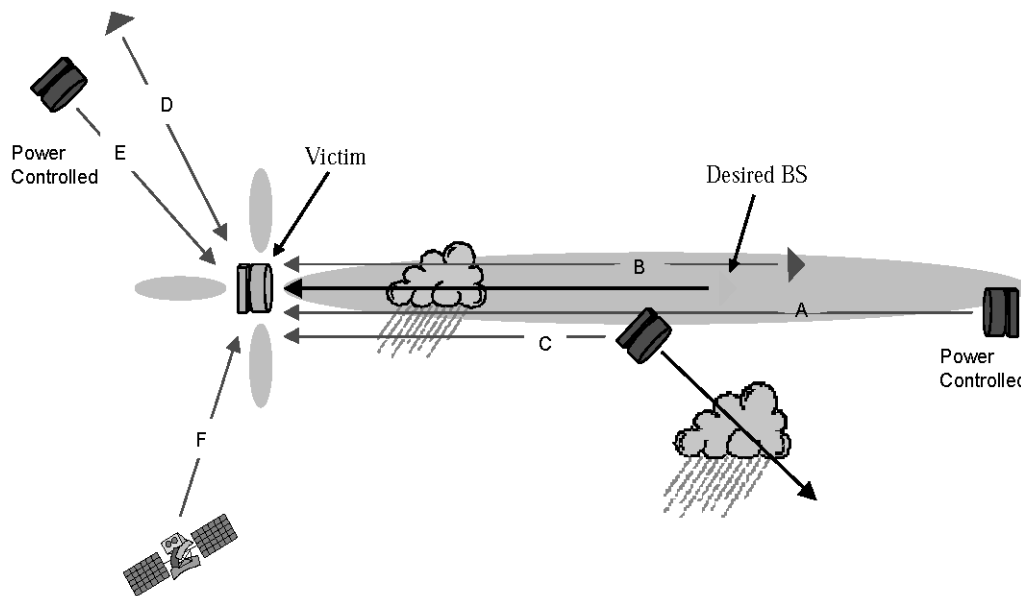


Figure 5—Interference sources to a FBWA SS

Case B covers BS-to-SS interference.

Case C covers the case of a narrow beam transmitter (FBWA or PTP) or satellite uplink at full power, due to rain in its path, but radiating from its sidelobe towards the victim. This case is more likely to occur than Case A because it could occur with any orientation of the interferer.

Case D covers BS-to-SS interference picked up by a sidelobe or backlobe of the victim. This case could be common because BSs radiate over wide areas, and this case could occur for any orientation of the victim.

Case E covers SS-to-SS interference picked up by a sidelobe or backlobe of the victim. Similar to reasoning in Case B and Case C for the victim BS, the worst case is likely to be with clear air in the backlobe, rain fading on the path from the desired BS, and the interfering SS pointing directly at the victim SS with maximum power.

Case F covers interference from a satellite downlink or stratospheric downlink. This case is not included in this recommended practice.

4.2.3.3 Victim omnidirectional mesh node

The potential interference sources for omnidirectional mesh nodes is shown in Figure 6. As this type of mesh deployment tends to have a relatively small footprint (a few kilometers) and is only feasible on frequencies below 11 GHz, the negative impact of rain cells will be minimal (less than 1 dB). Apart from the omnidirectional interference cases shown in Figure 6, mesh nodes may also employ sector (typically at the mesh BS) and highly directional antennas (possible at the edge of the coverage area), in which case the interference scenarios (particularly Case E and Case F) as specified for the BS (see 4.2.3.1) and all interference scenarios as defined for the SS (see 4.2.3.2) apply, respectively.

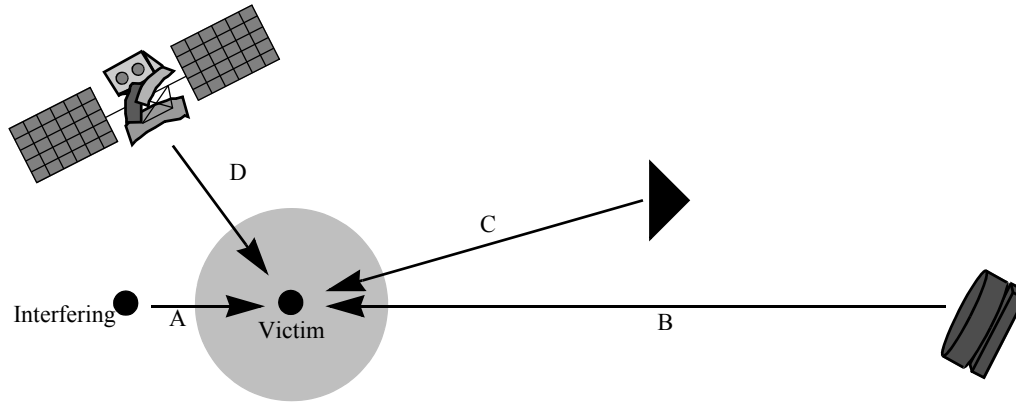


Figure 6—Interference sources to omnidirectional mesh system (BS and SS)

Case A shows mesh-node-to-mesh-node interference. This type of interference may occur in multicell deployments with low spectral reuse and on the boundary of provider coverage areas. In these cases, the victim node could tend to see the aggregate power of several interfering nodes. Compared to the BS-to-BS scenario as outlined in 4.2.3.1, this scenario would tend to be less severe due to the typical low elevation above clutter of this type of deployment, which results in significant NLOS attenuation.

Case B covers interference from a highly directional antenna system into the victim mesh node. The antenna system could be a PMP SS, part of a PTP link, or a mesh node in another cell or from another provider area. Interference energy could be mainly from the main lobe or from a sidelobe. LOS between the interfering and victim antenna is, however, relatively unlikely.

Case C covers interference from a PMP BS into the victim mesh node. This interference may occur on the boundary of coverage areas (same or different provider). The victim node could tend to see the aggregate power of several interfering PMP BSs. Due to the elevation of PMP BSs, LOS may exist. Similar to BS-to-BS interference, this source of interference tends to be most severe for mesh systems.

Case D covers interference from a satellite downlink or stratospheric downlink. This case is not included in this recommended practice.

5. Coexistence of FBWA systems in 23.5 GHz – 43.5 GHz

5.1 Introduction

This clause contains guidelines and recommendations for coexistence between various types of FBWA systems, operating in the 10–66 GHz frequency range. The guidelines and recommendations are supported by the results of a large number of simulations or representative interference cases. The full details of the simulation work are contained in input documents referenced in Annex A.

This clause analyzes coexistence using two scenarios:

- A CoCh scenario in which two operators are in either adjacent territories or territories within radio LOS of each other and have the same or overlapping spectrum allocation
- An AdjCh scenario in which the licensed territories of two operators overlap and they are assigned adjacent spectrum allocations

Coexistence issues may arise simultaneously from both scenarios as well as from these scenarios involving multiple operators. As a starting point for the consideration of tolerable levels of interference into FBWA systems, ITU-R Recommendation F.758-2 (2000-05) [B35] details two generally accepted values for the interference-to-thermal-noise ratio (I/N) for long-term interference into fixed service receivers. When considering interference from other services, it identifies an I/N value of -6 dB or -10 dB matched to specific requirements of individual systems. This approach provides a method for defining a tolerable limit that is independent of most characteristics of the victim receiver, apart from noise figure, and has been adopted for this recommended practice. The acceptability of any I/N value needs to be evaluated against the statistical nature of the interference environment. In arriving at the recommendations in this recommended practice, this evaluation has been carried out for $I/N = -6$ dB.

Subclause 5.8 provides interference mitigation measures that can be utilized to solve coexistence problems. Because of the wide variation in SS and BS distribution, radio emitter/receiver parameters, localized rain patterns, and the statistics of overlapping emissions in frequency and time, it is impossible to prescribe in this recommended practice which of the mitigation measures are appropriate to resolving a particular coexistence problem. In the application of these mitigation measures, identification of individual terminals or groups of terminals for modification is preferable to the imposition of pervasive restrictions.

Implementing the measures suggested in the recommendations will, besides improving the coexistence conditions, have a generally positive effect on intrasystem performance. Similarly, simulations performed in the preparation of this recommended practice suggest that most of the measures undertaken by an operator to promote intrasystem performance will also promote coexistence. It is outside the scope of this recommended practice to make recommendations that touch on intrasystem matters such as frequency plans and frequency reuse patterns. The results of further work carried out by Industry Canada (IC) are available in B.4.2 and B.6

5.2 Recommendations

5.2.1 Recommendation 1-1

Adopt a criterion of 6 dB below receiver thermal noise (i.e., $I/N \leq -6$ dB) in the victim receiver as an acceptable level of interference from a transmission of an operator in a neighboring area. This recommended practice recommends this value in recognition of the fact that it is not practical to insist upon an interference-free environment. Having once adopted this value, the following are some important consequences:

- Each operator accepts a 1 dB degradation [the difference in decibels between carrier-to-noise ratio (C/N) and $C/(N + I)$] in receiver sensitivity. In some regard, an I/N of -6 dB becomes the fundamental criterion for coexistence. The very nature of the MP system is that receivers must accept interference from intrasystem transmitters. Although a good practice would be to reduce the intrasystem interference level to be well below the thermal noise level (see Recommendation 1-6 in 5.2.6), this is not always feasible. The actual level of external interference could be higher than the limit stated above and still be neither controlling nor comparable to the operator's intrasystem interference. Thus, there is some degree of interference allocation that could be used to alleviate the coexistence problem.
- Depending upon the particular deployment environment, an operator's receiver may have interference contributions from multiple CoCh and AdjCh operators. Each operator should include design margin capable of simultaneously accepting the compound effect of interference from all other relevant operators. The design margin should be included preemptively at initial deployment, even if the operator in question is the first to deploy in a region and is not experiencing interference. All parties should recognize that, in predicting signal levels that result in the -6 dB interference value, it is difficult to be precise in including the aggregating effect of multiple terminals, the effect of uncorrelated rain, etc. Therefore, all parties should be prepared to investigate claims of interference even if the particular assessment method used to substantiate the -6 dB value predicts that there should not be any interference.

5.2.2 Recommendation 1-2

Each operator should take the initiative to collaborate with other known operators prior to initial deployment and prior to every relevant system modification. This recommendation should be followed even if an operator is the first to deploy in a region. To encourage this behavior for CoCh interference, this recommended practice introduces the concept of using power spectral flux density (psfd) values to trigger different levels of initiatives taken by an operator to give notification to other operators. The specific trigger values and their application to the two deployment scenarios are discussed in Recommendation 1-5 (see 5.2.5) and Recommendation 1-6 (see 5.2.6) and in 5.6.

5.2.3 Recommendation 1-3

In the resolution of coexistence issues, in principle, incumbents and first movers should coordinate with operators who deploy at a later time. In resolving coexistence issues, it is legitimate to weigh the capital investment an incumbent operator has made in his or her system. It is also legitimate to weigh the capital investment required by an incumbent operator for a change due to coexistence versus the capital investment costs that the new operator will incur.

The logic behind this recommendation is that some coexistence problems cannot be resolved simply by modifying the system of a new entrant into a region. Rather, they require the willingness of an incumbent to make modifications as well. It is recognized that this recommendation is especially challenging in the AdjCh scenario where overlapping territories imply that the incumbent and the late-comer may be competing for the same clients. The reality of some spectrum allocations is such that AdjCh operators will be allocated side-by-side frequency channels. This is an especially difficult coexistence problem to resolve without co-location of the operator's cell sites.

5.2.4 Recommendation 1-4

No coordination is needed in a given direction if the transmitter is greater than 60 km from either the service area boundary or the neighbor's boundary (if known) in that direction. Based on typical FBWA equipment parameters and an allowance for potential LOS interference couplings, subsequent analysis indicates that a 60 km boundary distance is sufficient to preclude the need for coordination. At lesser distances, coordination may be required, but this is subject to a detailed examination of the specific transmission path details that may provide for interference link excess loss or blockage. This coordination criterion is viewed to be necessary and appropriate for both systems that conform to this recommended practice and systems that do not.

5.2.5 Recommendation 1-5

(This recommendation applies to CoCh cases only.)

Recommendation 1-2 (see 5.2.2) introduced the concept of using psfd triggers as a stimulus for an operator to take certain initiatives to collaborate with his or her neighbor. It is recommended that regulators specify the applicable trigger values for each frequency band. If such recommendations are not specified, the following values may be adopted:

The coordination trigger values (see B.2) of $-114 \text{ dB(W/m}^2\text{)}$ in any 1 MHz band (24 GHz, 26 GHz, and 28 GHz bands) and $-111 \text{ dB(W/m}^2\text{)}$ in any 1 MHz band (38 GHz and 42 GHz bands) are employed in the initiative procedure described in Recommendation 1-6 (see 5.2.6). The evaluation point for the trigger exceedance may be at the victim operator's licensed area boundary, at the interfering operator's boundary, or at a defined point in between depending to some extent on the specific geographic circumstances of the BWA licensing. These values were derived as psfd values which, if present at a typical PMP BS antenna and typical receiver, would result in approximately the -6 dB interference value cited in Recommendation 1-1 (see 5.2.1). It should be emphasized that the trigger values are useful only as thresholds for taking certain

actions with other operators; they do not make an absolute statement as to whether there is interference potential.

5.2.6 Recommendation 1-6

(This recommendation applies to CoCh cases only.)

The triggers of Recommendation 1-5 (see 5.2.5) should be applied prior to deployment and prior to each relevant system modification. Should the trigger values be exceeded, the operator should try to modify the deployment to meet the trigger or, failing this, the operator should coordinate with the affected operator. Three existing coordination procedures are described in B.4, B.5, and B.6.

5.2.7 Recommendation 1-7

For same-area/AdjCh interference cases, analysis and simulation indicate that deployment may require an equivalent guard frequency between systems operating in close proximity and in adjacent frequency blocks. It is convenient to think of the guard frequency in terms of equivalent channels related to the systems operating at the edges of the neighboring frequency blocks. The amount of guard frequency depends on a variety of factors such as out-of-block (OOB) emission levels and in some cases is linked to the probability of interference in given deployment scenarios. Subclause 5.7 provides insight into some methods that can be employed to assess these situations, while 5.8 describes some possible interference mitigation techniques. These mitigation techniques include frequency guard bands, recognition of cross-polarization differences, antenna angular discrimination, spatial location differences, and frequency assignment substitution.

In most co-polarized cases, where the transmissions in each block are employing the same channel bandwidth, the guard frequency should be equal to one equivalent channel. Where the transmissions in neighboring blocks employ significantly different channel bandwidths, it is likely that a guard frequency equal to one equivalent channel of the widest bandwidth system will be adequate. However, analysis suggests that, under certain deployment circumstances, this may not offer sufficient protection and that a guard frequency equal to one channel at the edge of each operator's block may be required. Where administrations do not set aside guard channels, the affected operators would need to reach agreement on how the guard channel is apportioned between them. It is possible that, with careful and intelligent frequency planning, coordination, and/or use of orthogonal polarization or other mitigation techniques, all or partial use of this guard channel may be achieved. However, in order to minimize interference conflicts and at the same time maximize spectrum utilization, cooperative deployment between operators will be essential. This recommendation strongly proposes this.

5.2.8 Recommendation 1-8

Choose antennas for BS and SS appropriate to the degree of coexistence required. Examples of typical antenna masks that are satisfactory in most cases can be found in ETSI EN 301 215-1 (2001-08) [B11] and ETSI EN 301 215-2 (2002-06) [B12]. The coexistence simulations that led to the recommendations contained herein revealed that a majority of coexistence problems are the result of main beam interference. The sidelobe levels of the BS antennas are of a significant but secondary influence. The sidelobe levels of the subscriber antenna are of tertiary importance. In many cases, intrasystem considerations may place higher demands on antenna performance than required for intersystem coordination.

5.2.9 Recommendation 1-9

Limit maximum equivalent isotropically radiated power (EIRP) in accordance with recommendations in 5.5.1.1 and use SS power control in accordance with recommendations in 5.5.1.1.5. The interests of coexistence are served by reducing the amount of EIRP emitted by BSs, SSs, and RSs. The proposed maximum EIRP psd values are significantly less than allowed by some regulatory agencies, but should be an appropriate balance between constructing robust FBWA systems and promoting coexistence.

5.2.10 Recommendation 1-10

In conducting analyses to predict psfd and for coordination purposes, the following should be considered:

- a) Calculations of path loss to a point on the border should consider
 - 1) Clear air (no rain) plus relevant atmospheric absorption
 - 2) Intervening terrain blockage
- b) For the purpose of calculating psfd trigger compliance level, the psfd level at the service area boundary should be the maximum value that occurs at some elevation point up to 500 m above local terrain elevation. Equation (B.2) and Equation (B.3) in B.2 should be used to calculate the psfd limits.
- c) Actual electrical parameters (e.g., EIRP, antenna patterns) should be used.
- d) Clear sky propagation (maximum path length) conditions should be assumed. Where possible, use established ITU-R recommendations relating to propagation (e.g., ITU-R Recommendation P.452 (2001-02) [B38]).

5.3 Suggested guidelines for geographical and frequency spacing

Guidelines for geographical and frequency spacing of FBWA systems that would otherwise mutually interfere are given in 5.7.1 for each of a number of interfering mechanisms. This subclause summarizes the overall guidelines, taking into account all the identified interference mechanisms.

The two main deployment scenarios are as follows:

- CoCh systems that are geographically spaced
- Systems that overlap in coverage and (in general) require different frequencies of operation

The most severe of the several mechanisms that apply to each case determines the guideline spacing, as shown in Table 1. The guidelines are not meant to replace the coordination process described in 5.6. However, in many (probably most) cases, these guidelines will provide satisfactory psfd levels at system boundaries. The information is, therefore, valuable as a first step in planning the deployment of systems.

5.4 Medium overview

Electromagnetic propagation over the 10–66 GHz frequency range is relatively nondispersive, with occasional but increasingly severe rain attenuation as frequency increases. Absorption of emissions by terrain and human-generated structures is severe, leading to the normal requirement for optical LOS between transmit (Tx) and Rx antennas for satisfactory performance. Radio systems in this frequency regime are typically thermal or interference noise-limited (as opposed to multipath-limited) and have operational ranges of a few kilometers due to the large free-space loss and the sizable link margin that has to be reserved for rain loss. At the same time, the desire to deliver sizable amounts of capacity promotes the use of higher order modulation schemes with the attendant need for large carrier-to-interference ratio (C/I) for satisfactory operation. Consequently, the radio systems are vulnerable to interference from emissions well beyond their operational range. This is compounded by the fact that the rain cells producing the most severe rain losses are not uniformly distributed over the operational area. This creates the potential for scenarios in which the desired signal is severely attenuated, but the interfering signal is not.

Table 1—Summary of the guidelines for geographical and frequency spacing

Dominant interference path (Note 1)	Scenario	Spacing at which interference is below target level (generally 6 dB below receiver noise floor)
PMP BS to PMP BS	Adjacent area, same channel	60 km (Note 5)
Mesh SSs to PMP BS	Adjacent area, same channel	12 km (Note 2)
PMP BS to PMP BS	Same area, AdjCh	1 guard channel (Notes 3 and 5)
Mesh SSs to PMP SS	Same area, AdjCh	1 guard channel (Note 4)
NOTES 1—The dominant interference path is the path that requires the highest guideline geographical or frequency spacing. 2—The 12 km value is based on a BS at a typical 50 m height. For other values, the results change to some extent, but are always well below the 60 km value calculated for the PMP-PMP case. 3—The single guard channel spacing is based on both interfering and victim systems using the same channel size. Where the transmissions in neighboring blocks employ significantly different channel bandwidths, then it is likely that a guard frequency equal to one equivalent channel of the widest bandwidth system will be adequate. However, analysis suggests that, under certain deployment circumstances, this may not offer sufficient protection and that a guard frequency equal to one channel at the edge of each operator's block may be required. 4—The single guard channel spacing for mesh to PMP is based on both interfering and victim systems using the same channel size. This may be reduced in some circumstances. Where the transmissions in neighboring blocks employ significantly different channel bandwidths, it is likely that a guard frequency equal to one equivalent channel of the widest bandwidth system will be adequate. However, analysis suggests that, under certain deployment circumstances, this may not offer sufficient protection and that a guard frequency equal to one channel at the edge of each operator's block may be required. 5—In a case of harmonized FDD band plans and/or frequency reassignable TDD systems, the BS-to-BS case ceases to be dominant.		

5.5 Equipment design parameters

This clause provides recommendations for equipment design parameters that significantly affect interference levels and hence coexistence. Recommendations are made for the following FBWA equipment: BS equipment, SS equipment, RSs, and intercell links (including PTP equipment). Recommendations are for both transmitter and receiver portions of the equipment design. The recommended limits are applicable over the full range of environmental conditions for which the equipment is designed to operate, including temperature, humidity, input voltage, etc.

NOTE—The following design parameters apply to the frequency range 23.5–43.5 GHz, unless otherwise indicated.

5.5.1 Transmitter design parameters

This subclause provides recommendations for the design of both SS and BS transmitters to be deployed in FBWA systems. Recommendations are also made for RSs and intercell links.

5.5.1.1 Maximum EIRP psd limits

The degree of coexistence between systems depends on the emission levels of the various transmitters. Thus, it is important to recommend an upper limit on transmitted power, or, more accurately, a limit for the EIRP. Since PMP systems span very broad frequency bands and utilize many different channel bandwidths, a better measure of EIRP for coexistence purposes is in terms of psd expressed in dB(W/MHz) rather than simply power in dBW.

The following paragraphs provide recommended EIRP psd limits. These limits apply to the mean EIRP psd produced over any continuous burst of transmission. (Any pulsed transmission duty factor does not apply.)

The spectral density should be assessed with an integration bandwidth of 1 MHz; i.e., these limits apply over any 1 MHz bandwidth.

In preparing this recommended practice, emission limits from current (July 2000) US FCC, IC, and ITU-R regulations and recommendations were reviewed (in particular, US FCC Part 101 section 101.113, IC SRSP 324.25 (2000) [B27], IC SRSP 325.35 (2000) [B28], IC SRSP 338.6 (2000) [B29], ITU-R Recommendation F.1509 (02/01)⁴, ITU-R Recommendation F.746-6 (2002-05) [B34], ITU-R Recommendation F.758-2 (2000-05) [B35], and ITU-R Recommendation F.1249-1 (2000-05) [B36]). Table 2 depicts some example regulatory EIRP psd limits.

Although it is possible that the regulatory limits may be approached in the future, these emission limits are significantly higher (e.g., 15 dB) than supported by most currently available equipment. They are also significantly higher than those utilized by the coexistence simulations, which considered reasonable cell sizes, link budgets and availabilities and were the basis for the recommendations contained in this recommended practice. Table 2 compares regulatory limits to those used in simulations. Typical parameters used for the BS and in coexistence simulations for this recommended practice are as follows:

- Tx power: +24 dBm (−6 dBW)
- SS antenna gain: +34 dBi
- BS antenna gain: +19 dBi
- Carrier bandwidth: 28 MHz (+14.47 dB-MHz)

Table 2—Comparison of typical regulatory EIRP limits and simulation assumptions

Terminal	Example regulatory limits [dB(W/MHz)]	Simulation assumptions [dBW in 1 MHz]
BS	+14	−1.5
SS	+30	+13.5
PTP	+30	+25.0
RS facing BS	+30	Not performed
RS facing SS	+14	Not performed
Mesh	+30	0

It is recommended that any regulatory limits be viewed by the reader as future potential capabilities and that, where possible, actual deployments should use much lower EIRP psd values as suggested in 5.5.1.1.1 through 5.5.1.1.4. If systems are deployed using the maximum regulatory limits, they should receive a detailed interference assessment unless they are deployed in isolated locations, remote from adjacent operators. The assessment is needed to check consistency with the one guard channel recommendation for the same-area/AdjCh case (see Recommendation 1-7 in 5.2.7).

5.5.1.1.1 BS

A BS conforming to the recommendations of this recommended practice should not produce an EIRP psd exceeding +14 dBW in 1 MHz. However, it is strongly recommended that a maximum EIRP psd of 0 dBW in 1 MHz be used in order to comply with the one guard channel recommendation for the same-area/AdjCh

⁴Information on references can be found in Clause 2.

case (see Recommendation 1-7 in 5.2.7). The spectral density should be assessed with an integration bandwidth of 1 MHz; i.e., these limits apply over any 1 MHz bandwidth.

For the specific subband 25.25–25.75 GHz, the recommended BS EIRP spectral limits as stated in ITU-R Recommendation F.1509 (02/01) should be observed.

5.5.1.1.2 SS

A SS conforming to the recommendations of this recommended practice should not produce an EIRP psd exceeding +30 dBW in 1 MHz. However, it is strongly recommended that a maximum EIRP psd of +15 dBW in 1 MHz be used in order to comply with the one guard channel recommendation for the same-area/AdjCh case (see Recommendation 1-7 in 5.2.7). Note the stated limits apply to the SS operating under faded conditions (rain attenuation). Power control is recommended for unfaded conditions, as described in 5.5.1.1.5.

NOTE—For the specific subband 25.25–25.75 GHz, the recommended SS EIRP limits as stated in ITU-R Recommendation F.1509 (02/01) should be observed and are summarized as follows:

Transmitter of an SS in a FBWA system or transmitters of PTP fixed stations: Where practicable, the EIRP psd for each transmitter of an SS of a FBWA system, or transmitters of PTP fixed stations in the direction of any geostationary orbit (GSO) location specified in ITU-R SA.1276 [B46] for a data relay satellite (DRS), should not exceed +24 dBW in any 1 MHz.

5.5.1.1.3 Repeaters (RSs)

Several types of RSs are possible (see 4.1). From the point of view of EIRP psd limits, two recommendations are given, according to the direction faced by the RS and type of antenna used. The first recommended limit applies to situations where a RS uses a sectored or omnidirectional antenna, typically facing a number of SSs. The second case applies where a RS uses a highly directional antenna, typically facing a BS or single SS.

FBWA RS systems deploying directional antennas and conforming to the equipment requirements of this recommended practice should not produce an EIRP psd exceeding +30 dBW in 1 MHz. However, it is strongly recommended that a maximum EIRP psd of +15 dBW in 1 MHz be used in order to comply with the one guard channel recommendation for the same-area/AdjCh case (see Recommendation 1-7 in 5.2.7).

FBWA RSs deploying omnidirectional or sectored antennas and conforming to the equipment requirements of this recommended practice should not produce an EIRP psd exceeding +14 dBW in 1 MHz. However, it is strongly recommended that a maximum EIRP psd of 0 dBW in 1 MHz be used in order to comply with the one guard channel recommendation for the same-area/AdjCh case (see Recommendation 1-7 in 5.2.7).

5.5.1.1.4 In-band intercell links

An operator may employ PTP links that use AdjCh or CoCh frequencies and that are in the same geographical area as a PMP system. If the recommendations for SS EIRP in 5.5.1.1.2 and unwanted emissions in 5.5.1.3 are applied to these links, then they can operate within the coexistence framework described in this recommended practice. If not, then reevaluation of the coexistence recommendations is recommended.

5.5.1.1.5 Uplink power control

A SS conforming to the equipment design parameters recommended by this recommended practice should employ uplink power control with at least 15 dB of range. Simulation results described in other sections of this recommended practice demonstrate that such a range is necessary in order to facilitate coexistence.

5.5.1.1.6 Downlink power control

This recommended practice assumes that no active downlink power control is employed. However, it is recommended that the minimum power necessary to maintain the links be employed. In all cases, the recommended limits given in 5.5.1.1 should be met.

5.5.1.2 Frequency tolerance or stability

The system should operate within a frequency stability of ± 10 ppm.

NOTE—This specification is only for the purposes of complying with coexistence requirements. The stability requirements contained in the air interface specifications may be more stringent, particularly for the BS. In addition, it is highly recommended that the SS Tx frequency be controlled by using a signal from the downlink signal(s).

5.5.1.3 OOB unwanted emissions

Unwanted emissions produced by an operator's equipment and occurring totally within an operator's authorized block bandwidth are relevant only for that operator and are not considered in this recommended practice. Unwanted emissions from an operator that fall into adjacent bands are subject to the constraints set by regulatory authorities. These emission limits may or may not be sufficient to ensure that unacceptable levels of interference are avoided to users of adjacent spectrum.

It is appropriate to define acceptable coexistence criteria in terms of an interference coupling loss (ICL). ICL is the combination of net filter discrimination (NFD) and further isolation obtained by use of system interference mitigation techniques. NFD is represented by the transmission cascade of the out-of-band emissions from the interference source and the filter selectivity of the victim receiver. By itself, isolation obtained through NFD is not necessarily sufficient to ensure that acceptable interference coexistence criteria are achieved.

It is possible to identify ICL limits that define the necessary limits for acceptable coexistence. An example of the identification of such requirements may be found in ETSI TR 101 853 (2000-10) [B16]. Generally speaking, ICL requirements are controlled by the carriers that are located closest to the block edge. Establishment of necessary ICL limits can involve a number of interference mitigation techniques, employed singly or jointly, including

- Employing alternative polarization assignments for carriers located at block edge.
- Reducing the EIRP of carriers located on block edge.
- Establishing BS separation distance limits (BS-to-BS couplings).
- Reducing channel bandwidth assignments for carriers in proximity to block edge.
- Developing a full or partial guard band by not assigning carriers right up to block edge.

By employing a combination of the above techniques, it may be possible to operate without the need for a specific guard band. An operator may then be able to maximize use of spectrum within the assigned frequency block.

5.5.1.4 Unwanted emission levels specified in ETSI standards

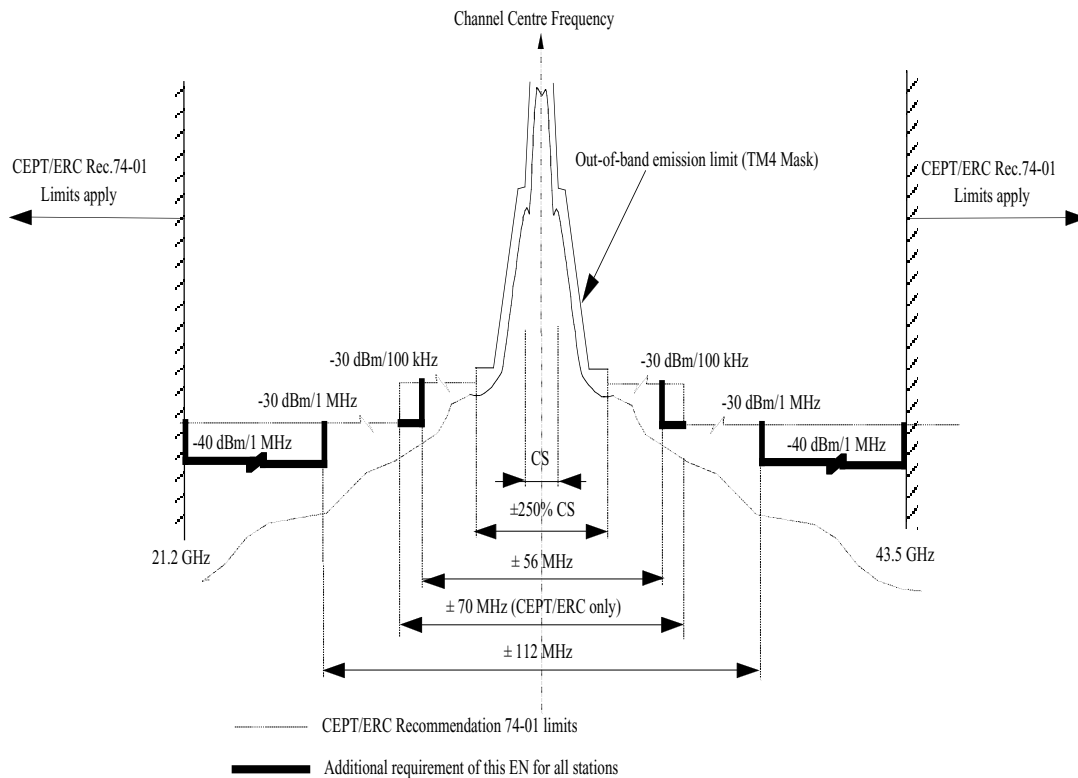
In regions where they apply, the limits of ETSI EN 301 390 (2003-11) should be followed.

Within $\pm 250\%$ of the channel, a specific spectrum mask applies. This should be taken from the appropriate standard documented by ETSI.

According to 4.1.3 in ETSI EN 301 390 (2003-11), the following requirements should be used in Europe:

- For spurious emissions in the frequency range from 9 kHz to 21.2 GHz and above 43.5 GHz, CEPT/ERC Recommendation 74-01 (2002) [B1] applies.
- For spurious emissions falling in the range from 21.2 GHz to 43.5 GHz, the tighter limits shown in Figure 7 and Figure 8 apply to both base and SSs. In this frequency range, where the -40 dBm limit shown in Figure 7 and Figure 8 applies, allowance is given for no more than 10 discrete continuous wave spurious emissions that are each permitted to exceed the limit up to -30 dBm.

In the same figures, for comparison, the less stringent limits from CEPT/ERC Recommendation 74-01 (2002) [B1] are also shown.

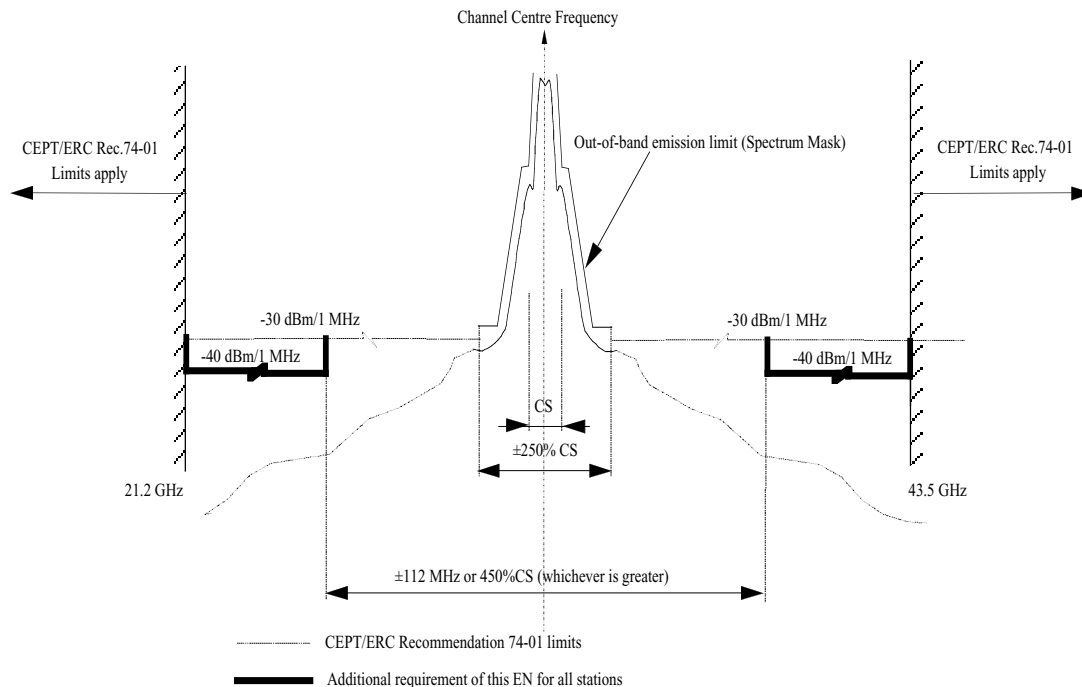


Source: ETSI 390 EN 301-390 V1.1.1. © ETSI 2000. Further use, modification, and redistribution is strictly prohibited. ETSI standards are available from publication@etsi.fr and <http://www.etsi.org/eds/eds.htm>.

Figure 7—Systems for channel separation (CS) $1 < CS \leq 10$ MHz

5.5.2 Receiver design parameters

This subclause provides recommendations for the design of both SS and BS receivers, which are to be deployed in FBWA systems. The parameters for which recommendations are made are those that affect performance in the presence of interference from other FBWA systems.



Source: ETSI 390 EN 301-390 V1.1.1. © ETSI 2000. Further use, modification, and redistribution is strictly prohibited. ETSI standards are available from publication@etsi.fr and <http://www.etsi.org/eds/eds.htm>.

Figure 8—Systems for CS > 10 MHz

5.5.2.1 CoCh interference tolerance

The simulations performed in support of the recommendations included in this recommended practice assume an interference signal level not exceeding 6 dB below the receiver noise floor causing a noise floor degradation of 1 dB. This was chosen as an acceptable degradation level upon which to operate a FBWA system while allowing interference levels to be specified in an acceptable manner. The following subclauses recommend minimum design standards to allow for interference.

These simulations do not account for an operator's specific equipment and frequency band. Operators should adjust the results to account for their own system parameters.

5.5.2.1.1 Base station (BS)

The BS receiver might be subjected to AdjCh interference and CoCh interference from other FBWA systems operating in close proximity to the reference system. Therefore, the BS receivers should be designed with proper selectivity and tolerance to interference.

5.5.2.1.2 Subscriber station (SS)

The SS receiver might be subjected to AdjCh interference and CoCh interference from other FBWA systems operating in the close proximity to the reference system. Therefore, the receivers intended for SS terminal applications should be designed with the proper selectivity and tolerance to interference.

5.5.2.1.3 Link availability in a joint $C/N + C/I$ transmission environment

From the simulation results described in other subclauses of this recommended practice, it has been found that some single interference coupling is usually dominant when worst-case interference levels are examined. Such worst-case impairments are expected to be rare as they require a boresight alignment between interference and victim antennas.

The simulation results indicate that the proposed receiver interference tolerance of a 1 dB threshold impairment is sufficient in terms of establishing acceptable coordination design objectives. However, the possibility still remains that multiple interferers can exist and may add to the threshold impairment. The following example examines the significance of these interference sources.

The system design model is based on the typical parameters for FBWA at 26 GHz as identified in 5.5.1.1. A 4-point quadrature amplitude modulation (4-QAM) system is assumed with an excess bandwidth of 15% and a receiver noise figure of 6 dB. Availability objectives of 99.995% for a bit error ratio (BER) = 10^{-6} , based on a threshold $C/N = 13$ dB, translate to a maximum cell radius of $R = 3.6$ km in ITU-R rain region K with a corresponding interference-free fade margin of 26 dB. Worst-case horizontally polarized transmission has been assumed.

For $I/N = -6$ dB, $C/I = 19$ dB, and the effective receiver threshold is impaired by approximately 1 dB so that the limiting C/N is now 14 dB. A 3 dB impairment to threshold ($C/I = 16$ dB) would move the C/N requirement to 16 dB. Figure 9 illustrates the reduction in availability as C/I increases, referenced to R fixed at 3.6 km. It is apparent that link availability degrades modestly as C/I increases. At $C/I = 16$ dB, availability has degraded to only 99.9925%.

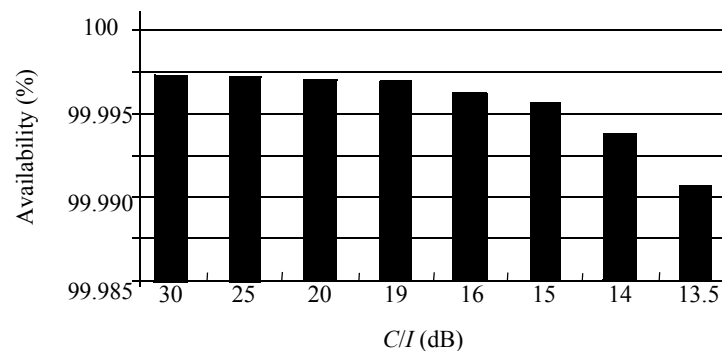


Figure 9—Availability versus C/I for a fixed cell radius for $R = 3.6$ km

Figure 10 indicates the necessary reduction in cell radius R that would be required to maintain availability at 99.995%. At $C/I = 16$ dB, R is reduced to 3.25 km, a reduction of 10%. Consequently, if system operation in a strong interference environment is anticipated, a system design with modestly reduced cell dimensions may be prudent.

It is thus concluded that the selected $I/N = -6$ dB is a conservative metric for specification of interference criteria.

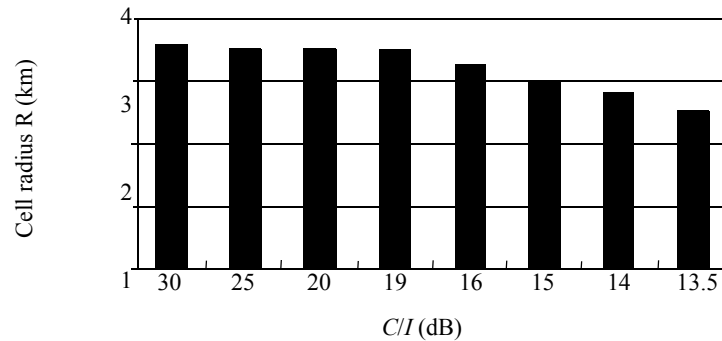


Figure 10—Radius versus C/I for a fixed availability of 99.995%

5.5.2.2 AdjCh desired to undesired signal level tolerance

Where coordination between operators cannot be guaranteed, it is recommended that an operational receiver be capable of withstanding the exposure of relatively high power AdjCh carriers. The recommended numerical values below are based on the emission mask in 5.5.1.3, quadrature phase shift keying (QPSK) modulation, and single-carrier operation. Coordination between operators will reduce the likelihood of this kind of interference.

This recommendation has a direct impact on coexistence referenced to the estimation of guard band requirements discussed extensively elsewhere in this recommended practice. The coexistence criteria assume that AdjCh carrier interference, as defined by NFD, establishes the requirements and that interfering signals have not degraded the NFD. Thus, the tests in 5.5.2.2.1 can be only indirectly related to the emission level masks and the guard band criteria recommended elsewhere in this recommended practice.

A possible test can be defined in terms of a ratio of desired carrier (D) to undesired carrier (U), D/U . The D emissions should correspond to the signal characteristics normally expected to be present at the victim receiver input port.

5.5.2.2.1 BS and SS D/U tolerance

This test should be performed with both desired and undesired signals having the same modulation characteristics and equal transmission bandwidths. With both the desired and undesired signals coupled to the input of the victim D receiver, set the input level of the desired signal so that it is 3 dB above the nominally specified BER performance threshold.

5.5.2.2.1.1 First AdjCh D/U

Set the undesired carrier frequency so that it corresponds to a one channel bandwidth frequency offset and at a $D/U = -5$ dB.

The measured BER performance of the D receiver should not exceed that specified for nominal threshold performance.

5.5.2.2.1.2 Second AdjCh D/U

Set the undesired carrier frequency so that it corresponds to a two channel bandwidth frequency offset and at a $D/U = -35$ dB.

The measured BER performance of the D receiver should not exceed that specified for nominal threshold performance.

Examples of suitable test methods can be found, such as those in ETSI conformance testing procedures (see B.1.3).

Where coordination between operators cannot be guaranteed, it is recommended that an operational receiver be capable of withstanding the exposure of relatively high-power AdjCh carriers.

5.6 Deployment and coordination

This subclause provides a recommended structure process to be used to coordinate deployment of FBWA systems in order to minimize interference problems.

NOTE—National regulation and/or international agreements may impose tighter limits than the following and take precedence in this case.

This methodology will facilitate identification of potential interference issues and, if the appropriate recommendations are followed, will minimize the impact in many cases, but compliance with this process will not guarantee the absence of interference problems.

NOTE—In the following, *coordination* implies, as a minimum, a simple assessment showing the likelihood of interference. It may imply a detailed negotiation between operators to mitigate problem areas for the benefit of both systems.

5.6.1 CoCh/adjacent-area case

5.6.1.1 Methodology

Coordination is recommended between licensed service areas where both systems are operating CoCh, i.e., over the same FBWA frequencies, and where the service areas are in close proximity, e.g., the shortest distance between the respective service boundaries is less than 60 km.⁵ The rationale for 60 km is given in 5.6.1.2. The operators are encouraged to arrive at mutually acceptable sharing agreements that would allow for the provision of service by each licensee within its service area to the maximum extent possible.

Under the circumstances where a sharing agreement between operators does not exist or has not been concluded and where service areas are in close proximity, a coordination process should be employed. In addition to the procedure described in the following paragraph, two alternative coordination procedures are described in B.5 (based on a different I/N) and B.6 (based on a two-tier psfd approach).

FBWA operators should calculate the psfd at their own service area boundary, taking into account such factors as propagation loss, atmospheric loss, antenna directivity toward the service area boundary, and the curvature of Earth. The psfd level at the service area boundary should be the maximum value for elevation point up to 500 m above local terrain elevation. No aggregation is needed because principal interference processes are direct main-beam-to-main-beam coupling. Refer to 5.6.1.2 for a rationale behind the psfd levels presented in this process. The limits here refer to an operator's own service boundary, because that is known to the operator and will frequently be the same as the adjacent operator's service boundary. In cases where the two boundaries are separate (e.g., by a large lake), dialog between operators, as part of the coordination process, should investigate relaxing the limits by applying the limits at the adjacent service boundary. In cases where there is an intervening land mass (with no licensed operator) separating the two

⁵In the case of sites of very high elevation relative to local terrain, BWA service areas beyond 60 km may be affected. The operator should coordinate with the affected licensee(s).

service areas, a similar relaxation could be applied. However, in this case, caution is needed because both existing operators may have to reengineer their systems if service later begins in this intervening land mass.

Deployment of facilities that generate a psfd, averaged over any 1 MHz at their own service area boundary, less than or equal to that stated in Table 3, should not be subject to any coordination requirements.

Table 3—Maximum psfd limits

Frequency band (GHz)	psfd dB[(W/m ²)/MHz]
24, 26, 28	−114
38, 42	−111

5.6.1.2 Coordination trigger

As described in 5.6.1.1, distance is suggested as the first trigger mechanism for coordination between adjacent licensed operators. If the boundaries of two service areas are within 60 km of each other, then the coordination process is recommended.

The rationale for 60 km is based upon several considerations, including radio horizon calculations, propagation effects, and pfd levels. The last consideration is discussed in 5.6.3.

The radio horizon, defined as the maximum LOS distance between two radios, is defined (see Figure 11) as follows:

$$R_h = 4.12(\sqrt{h_1} + \sqrt{h_2}) \quad (1)$$

where

- R_h is radio horizon (km),
- h_1 is height of Radio 1 above clutter (m),
- h_2 is height of Radio 2 above clutter (m).

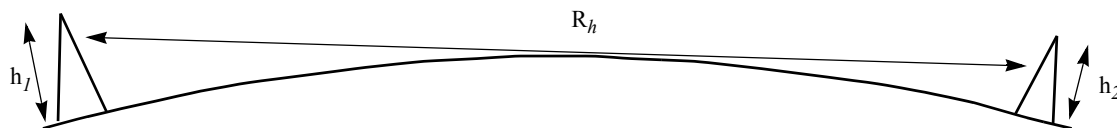


Figure 11—Geometry of radio horizon

Table 4 presents the horizon range for different radio heights above average clutter. Note that if the antenna is erected on a mountain (or building), then the height of radio above clutter will probably also include the height of the mountain (or building).

Table 4—Horizon range for different radio heights above ground level (in km)

Height of Radio 2 above clutter m)	Height of Radio 1 above clutter (m)								
	10	20	30	40	50	60	70	80	90
10	26	31	36	39	42	45	47	50	52
20	31	37	41	44	48	50	53	55	58
30	36	41	45	49	52	54	57	59	62
40	39	44	49	52	55	58	61	63	65
50	42	48	52	55	58	61	64	66	68
60	45	50	54	58	61	64	66	69	71
70	47	53	57	61	64	66	69	71	74
80	50	55	59	63	66	69	71	74	76
90	52	58	62	65	68	71	74	76	78

The worst-case interference scenario involves two BSs, as these are typically located on relatively high buildings or infrastructures and hence have greater radio horizon distances than SSs. A typical height for a BS is 65 m above ground level, or 55 m above clutter, assuming an average clutter height of 10 m over the whole path length. This produces a radio horizon of 60 km. There will be cases where the BS equipment may be located on higher buildings, which would produce a greater radio horizon. However, these BSs tend to tilt their antennas downward. This effectively reduces the amount of power directed towards the adjacent BS and, therefore, reduces the interference. The following subclauses examine power levels in further detail.

5.6.2 Same-area/adjacent-frequency case

As stated in Recommendation 1-7 (see 5.2.7), deployments will usually need one guard channel between nearby transmitters. Where administrations do not set aside guard channels, the affected operators would need to reach agreement on how the guard channel is apportioned between them. Where channel sizes are different, the guard channel should be equal to the size of the wider channel system. This recommended practice does not consider the case where an operator deploys multiple channel sizes within his or her allocation.

5.6.3 Use of psfd as a coexistence metric

This subclause addresses the maximum pfd that can be tolerated as a result of CoCh interference originating from an adjacent licensed operator. For the purposes of the recommendations in this recommended practice, the amount of interference generally considered acceptable or tolerable is a level that produces a degradation of 1 dB to the system's C/N . This degradation is usually taken into consideration during the original link budget exercise. For the noise floor to increase by 1 dB, the interference power level must be 6 dB below the receiver's thermal noise floor.

In B.2, a typical psfd calculation is shown at frequencies of 28 GHz and 38 GHz. The psfd limit can be applied in different ways that affect the probability of interference. Two examples are given in B.2 and B.7.

The 38 GHz band has been used extensively for individual PTP radio links for a number of years in many countries. More recently, the band has also been used to provide PTP links in support of FBWA systems. Thus, it is important that these PTP radio receivers be afforded an equal opportunity to coexist with PMP equipment in a shared frequency environment. Where there is significant deployment of PTP links as well as