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## Editors' Preface

It is rather difficult to consider a new publication on mobile radio as an actual novel book, due to the proliferation of literature and contributions on this subject. Nevertheless, the turbulence of the environment and the fast development of mobile communications world tend to make any publication rapidly obsolete and subsequently a dissemination of up-to-date information is required. In such a context, this book may be considered as an excellent synthesis of the fresh achievements resulting from the activities carried out during the past six years by a huge number of European experts in different areas of wireless communications. The contributors come from about a hundred of different Institutions, such as public and private operators, universities, research bodies, manufacturers, involved at various levels in COST Action 231, "*Evolution of Land Mobile Radio (including personal) Communications*", aimed at identifying the most likely migration paths from current cellular networks towards next generation universal systems.

The book, which summarises the most significant results obtained by such a group of distinguished experts, covers a wide range of topics, starting from radio system aspects (investigating and comparing various access, modulation and coding schemes), going through propagation issues (considering measurements, models and simulation tools related to different environments, from macro- to micro- and pico-cell coverage), to end with broadband communications services (i.e., services requiring a capacity greater than that of the basic ISDN services), which involve a large spectrum of new telecom technologies at high microwave and millimetre wave bands for short range applications. Accordingly, the ambitious goal of this book is on one side to give a general overview of the ongoing researches in Europe to support the deployment of trans-European and world-wide systems and the development of specifications for future generation systems currently in progress within standardisation bodies. In addition, on the other side, the objective is to present novel approaches to face problems that such development may pose, and in several cases to suggest solutions which have been made possible only by the continuous interactions among the members of the Action and the stimulating discussions occurred within the three Working Groups created by the Management Committee.

In fact, COST, "European Co-operation in the field of Scientific and Technical research", is a framework for the preparation and implementation of European projects involving applied scientific research, within European Countries (but not limited to the European Union Member States) having signed the so-called "COST Treaty". Such COST framework was used to set up specific "projects", within several activity domains, from Agriculture to Chemistry, Environment, Food technology, Medical research, Meteorology, Transport, etc. Recently events in Central and Eastern Europe have made the original list of members somewhat

obsolete: COST now involves 26 states, but the principles have remained mostly unchanged, and each signatory enjoys the same rights and privileges within COST. This is in agreement with the spirit of the initiative, which is to stimulate "cross-fertilisation" across all the organisations having interests in a given field. Financing of researches is in fact provided by each member state (and very often by each organisation involved in the Projects), while the co-ordination costs are funded by both the participating countries and the European Commission. A special feature of all COST Actions is the complete freedom of participation of each country involved: any COST country can join any Action by signing the "Memorandum of Understanding" (MoU), which is the formal basis of each Action.

In such a context, COST Telecommunications Actions have an important role to play in the development of our networked society. They should be proactive in the challenging times presented by these rapid changes: not only COST must be at the forefront of research, but it also must ensure that the broad international collaborative perspective be maintained. COST Actions have to investigate those technologies most appropriate to the future environment, so as to minimise potential duplication of research and maximise the size of the eventual marketplace. COST Telecommunications in fact involve research topics that are strategic to the development of the information society. These areas include radio and optical communications, signal processing, future user requirements, to name but a few.

As said before, COST Actions are funded nationally either by the member states or the participating institutions, in contrast to other European researches, such as RACE Projects in the recent past and ACTS projects nowadays, which are funded by the European Union. Such a voluntary form of collaboration which does not require an "a priori" agreed overall research policy, in conjunction with the "bottom-up" principle which distinguishes all COST Actions, allowed in particular COST 231 to focus on several themes of personal communications, on the only condition that the activities are approved by the internal Management Committee which is responsible for administering the Action.

As a matter of fact, this is not a book for students or a text for senior level or advanced graduate courses, although its completeness and the comprehensive approach to the world of mobile and personal communications might make it useful also for this specific purpose. The original intention of COST 231 Management Committee was to address a much wider audience, not limited to the scientific/technical level, but including also operators, manufacturers and regulatory bodies at the managing level, in order to bear witness of what an heterogeneous group working on a pure voluntary basis, but stimulated by common aims and interests, can obtain in a free environment. Furthermore, a not negligible result could also to provide all the potential players in the mobile radio scenario with suitable guidelines and tools for a correct understanding of what are the most likely and fruitful current paths in the somewhat confusing (but intriguing) situation. In this respect, as editors of this book, we are proud to introduce a work which can be considered at least at the same level of an outstanding forerunner, COST Action 207, which played a unique role in supporting the Group Spécial Mobiles in their work

that led to the definition (and subsequent world-wide implementation) of the Global System for Mobile Communications (GSM).

A special acknowledgement is made to the invaluable work of the vast group of contributors, authors and co-editors, whose commitment to the common cause made it possible to edit the text, notwithstanding the difficulties in reaching a sufficient degree of harmonisation of the contents and avoiding at the same time any drawback due to potential duplication or overlapping. Many thanks in particular to the former Chairman, Mr. P. Porzio Giusto, the Vice-Chairman, Mr. G. de Brito, to the Working Groups Chairmen (Prof. J. Bach Andersen, Prof. S.K. Barton, Mr. R.J. Goodwin, Mr. P. Porzio Giusto, Prof. P.A. Watson) for their co-ordination efforts and the excellent management work during the entire life of the Action. The edition of this book was initiated by Eraldo Damosso, which unfortunately could not finish it, due to health problems, hence being terminated by Luis M. Correia and taking much more time than it was supposed to; as a consequence, some chapter editors had to be replaced in the middle of the editing process, and new ones had to be found - to those who accepted the challenging task of finishing the edition of chapters in difficult circumstances a special word of acknowledgement. Finally, last but not least, our sincere thanks to the whole COST 231 Management Committee for submitting contributions which served as a basis for this book and for the useful discussions which resulted into a significant improvement of the original text.

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*(Chairman, COST 231)*  
*Luis M Correia*



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## List of Acronyms

ACCH	<u>A</u> ssociated <u>C</u> ontrol <u>C</u> hannel
ACF	<u>A</u> uto- <u>C</u> orrelation <u>F</u> unction
ACI	<u>A</u> djacent- <u>C</u> hannel <u>I</u> nterference
ACTS	<u>A</u> dvanced <u>C</u> ommunications <u>T</u> echnologies and <u>S</u> ervices
ADC	<u>A</u> nalogue to <u>D</u> igital <u>C</u> onverter
ADPCM	<u>A</u> daptive <u>D</u> ifferential <u>P</u> ulse <u>C</u> ode <u>M</u> odulation
AMPS	<u>A</u> dvanced <u>M</u> obile <u>P</u> hone <u>S</u> ystem
ATDMA	<u>A</u> dvanced TDMA
ATDMA	<u>A</u> dvanced <u>T</u> DMA <u>M</u> obile <u>A</u> ccess (RACE project)
ATM	<u>A</u> synchronous <u>T</u> ransfer <u>M</u> ode
AWGN	<u>A</u> dditive <u>W</u> hite <u>G</u> aussian <u>N</u> oise
BCCH	<u>B</u> roadcast <u>C</u> ontrol <u>C</u> hannel
BDFE	<u>B</u> lock <u>D</u> ecision <u>F</u> eedback <u>E</u> qualiser
BER	<u>B</u> it <u>E</u> rror <u>R</u> ate
B-ISDN	<u>B</u> roadband ISDN
BLE	<u>B</u> lock <u>L</u> inear <u>E</u> qualiser
BPSK	<u>B</u> inary PSK
BS	<u>B</u> ase <u>S</u> tation
BTS	<u>B</u> ase <u>T</u> ransceiver <u>S</u> tation
CCI	<u>C</u> o- <u>c</u> hannel <u>I</u> nterference
CDF	<u>C</u> umulative <u>D</u> istribution <u>F</u> unction
CDMA	<u>C</u> ode <u>D</u> ivision <u>M</u> ultiple <u>A</u> ccess
CENELEC	<u>C</u> omité <u>E</u> uropéen de <u>N</u> ormalisation <u>É</u> lectronique
CEPT	<u>C</u> onference of <u>E</u> uropean <u>P</u> ostal and <u>T</u> elecommunications Administrations
CF	<u>C</u> orrelation <u>F</u> unction
CG	<u>C</u> onjugate <u>G</u> radient
CIR	<u>C</u> arrier to <u>I</u> nterference <u>R</u> atio
CIR	<u>C</u> hannel <u>I</u> mpulse <u>R</u> esponse
CNR	<u>C</u> arrier to <u>N</u> oise <u>R</u> atio
CODIT	<u>C</u> ode <u>D</u> ivision <u>T</u> estbed for UMTS (RACE project)
COST	European <u>C</u> o-operation in the Field of <u>S</u> cientific and <u>T</u> echnical Research

CPM	<u>C</u> ontinuous <u>P</u> hase <u>M</u> odulation
CR	<u>C</u> hannel <u>R</u> esponse
CRC	<u>C</u> yclic <u>R</u> edundancy <u>C</u> heck
CSMA/CD	<u>C</u> arrier <u>S</u> ense <u>M</u> ultiple <u>A</u> ccess with <u>C</u> ollision <u>D</u> etection
CTS	<u>C</u> lear to <u>S</u> end
CW	<u>C</u> ontinuous <u>W</u> ave
DAC	<u>D</u> igital to <u>A</u> nalogue <u>C</u> onverter
DCA	<u>D</u> ynamic <u>C</u> hannel <u>A</u> llocation
DCS	<u>D</u> igital <u>C</u> ellular <u>S</u> ystem
DECT	<u>D</u> igital <u>E</u> nhanced <u>C</u> ordless <u>T</u> elecommunications
DFE	<u>D</u> ecision <u>F</u> eedback <u>E</u> qualiser
DFE	<u>D</u> ecision <u>F</u> eedback <u>E</u> stimation
DFSE	<u>D</u> ecision <u>F</u> eedback <u>S</u> equence <u>E</u> stimation
DLC	<u>D</u> ata <u>L</u> ink <u>C</u> ontrol
DOA	<u>D</u> irection of <u>A</u> rrival
DPSK	<u>D</u> ifferential PSK
DS	<u>D</u> irect <u>S</u> equence
DSP	<u>D</u> igital <u>S</u> ignal <u>P</u> rocessing
DTX	<u>D</u> iscontinuous <u>T</u> ransmission
EGC	<u>E</u> qual <u>G</u> ain <u>C</u> ombining
EMC	<u>E</u> lectromagnetic <u>C</u> ompatibilty
ERC	<u>E</u> uropean <u>R</u> adiocommunications <u>C</u> ommittee
ERMES	<u>E</u> uropean <u>R</u> adio <u>M</u> essage <u>S</u> ystem
ERO	<u>E</u> uropean <u>R</u> adiocommunications <u>O</u> ffice
ETSI	<u>E</u> uropean <u>T</u> elecommunications <u>S</u> tandards <u>I</u> nstitute
ETSI/RES	ETSI / <u>R</u> adio <u>E</u> quipment & <u>S</u> ystems
ETSI/SMG	ETSI / <u>S</u> pecial <u>M</u> obile <u>G</u> roup
FCA	<u>F</u> ixed <u>C</u> hannel <u>A</u> llocation
FDD	<u>F</u> requency <u>D</u> ivision <u>D</u> uplex
FDDSF	<u>F</u> ield <u>D</u> irection- <u>D</u> elay- <u>S</u> pread <u>F</u> unction
FDM	<u>F</u> requency <u>D</u> ivision <u>M</u> ultiplex
FDMA	<u>F</u> requency <u>D</u> ivision <u>M</u> ultiple <u>A</u> ccess
FEC	<u>F</u> orward <u>E</u> rror <u>C</u> orrection
FER	<u>F</u> rame <u>E</u> rasure <u>R</u> ate
FH	<u>F</u> requency <u>H</u> opping
FIR	<u>F</u> inite <u>I</u> mpulse <u>R</u> esponse
FM	<u>F</u> requency <u>M</u> odulation

FPLMTS	<u>F</u> uture <u>P</u> ublic <u>L</u> and <u>M</u> obile <u>T</u> elecommunication <u>S</u> ystems
FS	<u>F</u> ull-rate <u>S</u> peech
GEO	<u>G</u> eosynchronous <u>O</u> rbit
GMSK	<u>G</u> aussian MSK
GO	<u>G</u> eometrical <u>O</u> ptics
GOS	<u>G</u> rade of <u>S</u> ervice
GSM	<u>G</u> lobal <u>S</u> ystem for <u>M</u> obile Communications
HCA	<u>H</u> ybrid <u>C</u> hannel <u>A</u> llocation
HEO	<u>H</u> igh <u>E</u> lliptical <u>O</u> rbit
HIPERLAN	<u>H</u> igh <u>P</u> erformance <u>R</u> adio LAN
HS	<u>H</u> alf-rate <u>S</u> peech
HT	<u>H</u> illy <u>T</u> errain
IBC	<u>I</u> ntegrated <u>B</u> roadband <u>C</u> ommunications
IC	<u>I</u> nterference <u>C</u> ancellation
IMT-2000	<u>I</u> nternational <u>M</u> obile <u>T</u> elecommunications - 2000
IN	<u>I</u> ntelligent <u>N</u> etwork
INIRC	<u>I</u> nternational <u>N</u> on- <u>I</u> onising <u>R</u> adiation <u>C</u> ommittee
IR	<u>I</u> nfra <u>R</u> ed
IR	<u>I</u> mpulse <u>R</u> esponse
IRPA	<u>I</u> nternational <u>R</u> adio <u>P</u> rotection <u>A</u> ssociation
ISDN	<u>I</u> ntegrated <u>S</u> ervices <u>D</u> igital <u>N</u> etwork
ISI	<u>I</u> nter- <u>S</u> ymbol <u>I</u> nterference
ISM	<u>I</u> ndustrial, <u>S</u> cientific and <u>M</u> edical (frequency bands)
ISMA	<u>I</u> nhibit <u>S</u> ense <u>M</u> ultiple <u>A</u> ccess
ITU	<u>I</u> nternational <u>T</u> elecommunications <u>U</u> nion
ITU-R	ITU - <u>R</u> adiocommunications sector
JD	<u>J</u> oint <u>D</u> etection
LAN	<u>L</u> ocal <u>A</u> rea <u>N</u> etwork
LEO	<u>L</u> ow <u>E</u> arth <u>O</u> rbit
LINC	<u>L</u> inear Amplification with <u>N</u> on-linear <u>C</u> omponents
LMS	<u>L</u> east <u>M</u> ean <u>S</u> quare
LOS	<u>L</u> ine-of- <u>S</u> ight
LT	<u>L</u> ong <u>T</u> erm
MAC	<u>M</u> edium <u>A</u> ccess <u>C</u> ontrol
MAMSK	<u>M</u> ulti- <u>A</u> mplitude MSK
MAQMSK	<u>M</u> ulti- <u>A</u> mplitude QMSK
MAVT	<u>M</u> obile <u>A</u> udio <u>V</u> isual <u>T</u> erminal (RACE project)

MBS	<u>M</u> obile <u>B</u> roadband <u>S</u> ystem
MBS	<u>M</u> obile <u>B</u> roadband <u>S</u> ystem (RACE project)
MLSE	<u>M</u> aximum <u>L</u> ikelihood <u>S</u> equence <u>E</u> stimator
MMSE	<u>M</u> inimum <u>M</u> ean <u>S</u> quare <u>E</u> rror
MoM	<u>M</u> ethod of <u>M</u> oments
MONET	<u>M</u> obile <u>N</u> etwork (RACE project)
MoU	<u>M</u> emorandum of <u>U</u> nderstanding
MPSK	<u>M</u> ultilevel PSK
MQAM	<u>M</u> ultilevel QAM
MRC	<u>M</u> aximal <u>R</u> atio <u>C</u> ombining
MS	<u>M</u> obile <u>S</u> tation
MSK	<u>M</u> inimum <u>S</u> hift <u>K</u> eying
MTLL	<u>M</u> ean <u>T</u> ime to <u>L</u> oose <u>L</u> ock
MUSIC	<u>M</u> ultiple <u>S</u> ignal <u>C</u> lassification
NEC	<u>N</u> umerical <u>E</u> lectromagnetic <u>C</u> ode
NLOS	<u>N</u> on-LOS
NRP	<u>N</u> ormalised <u>R</u> eceived <u>P</u> ower
OFDM	<u>O</u> rthogonal <u>F</u> requency <u>D</u> ivision <u>M</u> ultiplexing
OLOS	<u>O</u> bstructed LOS
PAP	<u>P</u> ower <u>A</u> ngular <u>P</u> rofile
PCMCIA	<u>P</u> ersonal <u>C</u> omputer <u>M</u> odule <u>C</u> ard <u>I</u> ndustry <u>A</u> ssociation
PCS	<u>P</u> ersonal <u>C</u> ommunication <u>S</u> ervices
PDA	<u>P</u> ersonal <u>D</u> igital <u>A</u> ssistant
PDP	<u>P</u> ower <u>D</u> elay <u>P</u> rofile
PIC	<u>P</u> ersonal <u>I</u> ntelligent <u>C</u> ommunicator
PIFA	<u>P</u> lanar <u>I</u> nverted <u>F</u> <u>A</u> ntenna
PRMA	<u>P</u> acket <u>R</u> eservation <u>M</u> ultiple <u>A</u> ccess
PSK	<u>P</u> hase <u>S</u> hift <u>K</u> eying
PSTN	<u>P</u> ublic <u>S</u> witched <u>T</u> elephone <u>N</u> etwork
QAM	<u>Q</u> uadrature <u>A</u> mplitude <u>M</u> odulation
QC	<u>Q</u> uasi <u>C</u> oherent
QMSK	<u>Q</u> uadrature MSK
QOS	<u>Q</u> uality of <u>S</u> ervice
QPSK	<u>Q</u> uaternary PSK
RA	<u>R</u> ural <u>A</u> rea
RACE	<u>R</u> esearch and Technology Development in <u>A</u> dvanced Communication Technologies in <u>E</u> urope
RDS	<u>R</u> MS <u>D</u> elay <u>S</u> pread

RF	<u>R</u> adio <u>F</u> requency
RLL	<u>R</u> adio <u>L</u> ocal <u>L</u> oop
RLS	<u>R</u> ecursive <u>L</u> east <u>S</u> quare
RMS	<u>R</u> oot <u>M</u> ean <u>S</u> quare
RS	<u>R</u> emote <u>S</u> tation
RS	<u>R</u> eed <u>S</u> olomon
RSSI	<u>R</u> eceiver <u>S</u> ignal <u>S</u> trength <u>I</u> ndicator
RTS	<u>R</u> equest to <u>S</u> end
RX	<u>R</u> eceiver
SAINT	<u>S</u> atellite <u>I</u> ntegration in the Future Mobile Network (RACE project)
SAR	<u>S</u> pecific <u>A</u> bsorption <u>R</u> ate
SAW	<u>S</u> urface <u>A</u> coustic <u>W</u> ave
SC	<u>S</u> election <u>C</u> ombining
SCPC	<u>S</u> ingle <u>C</u> hannel per <u>C</u> arrier
SDMA	<u>S</u> pace <u>D</u> ivision <u>M</u> ultiple <u>A</u> ccess
SFH	<u>S</u> low <u>F</u> requency <u>H</u> opping
SIP	<u>S</u> pectral <u>I</u> ncremental <u>P</u> ropagation
SNR	<u>S</u> ignal to <u>N</u> oise <u>R</u> atio
ST	<u>S</u> hort <u>T</u> erm
SWR	<u>S</u> tanding <u>W</u> ave <u>R</u> atio
TCH	<u>T</u> raffic <u>C</u> hannel
TCM	<u>T</u> rellis <u>C</u> oded <u>M</u> odulation
TDD	<u>T</u> ime <u>D</u> ivision <u>D</u> uplex
TDMA	<u>T</u> ime <u>D</u> ivision <u>M</u> ultiple <u>A</u> ccess
TSUNAMI	<u>T</u> echnology in <u>S</u> mart Antennas for <u>U</u> niversal <u>A</u> dvanced <u>M</u> obile <u>I</u> nfrastructure (RACE project)
TU	<u>T</u> ypical <u>U</u> rban
TX	<u>T</u> ransmitter
UMTS	<u>U</u> niversal <u>M</u> obile <u>T</u> elecommunications <u>S</u> ystem
UPT	<u>U</u> niversal <u>P</u> ersonal <u>T</u> elecommunications
VAD	<u>V</u> oice <u>A</u> ctivity <u>D</u> etection
VDFA	<u>V</u> ector <u>D</u> ecision <u>F</u> eedback <u>E</u> qualiser
VLSI	<u>V</u> ery <u>L</u> arge <u>S</u> cale <u>I</u> ntegration
VSWR	<u>V</u> oltage SWR
WARC	<u>W</u> orld <u>A</u> ministrative <u>R</u> adio <u>C</u> onference
WHO	<u>W</u> orld <u>H</u> ealth <u>O</u> rganisation
WLAN	<u>W</u> ireless LAN
WPBX	<u>W</u> ireless <u>P</u> rivate <u>B</u> ranch <u>E</u> xchange

WSSUS	<u>W</u> ide- <u>S</u> ense- <u>S</u> tationary <u>U</u> ncorrelated <u>S</u> cattering
XP	Cross <u>P</u> olarisation <u>D</u> iscrimination
ZF	<u>Z</u> ero <u>F</u> orcing