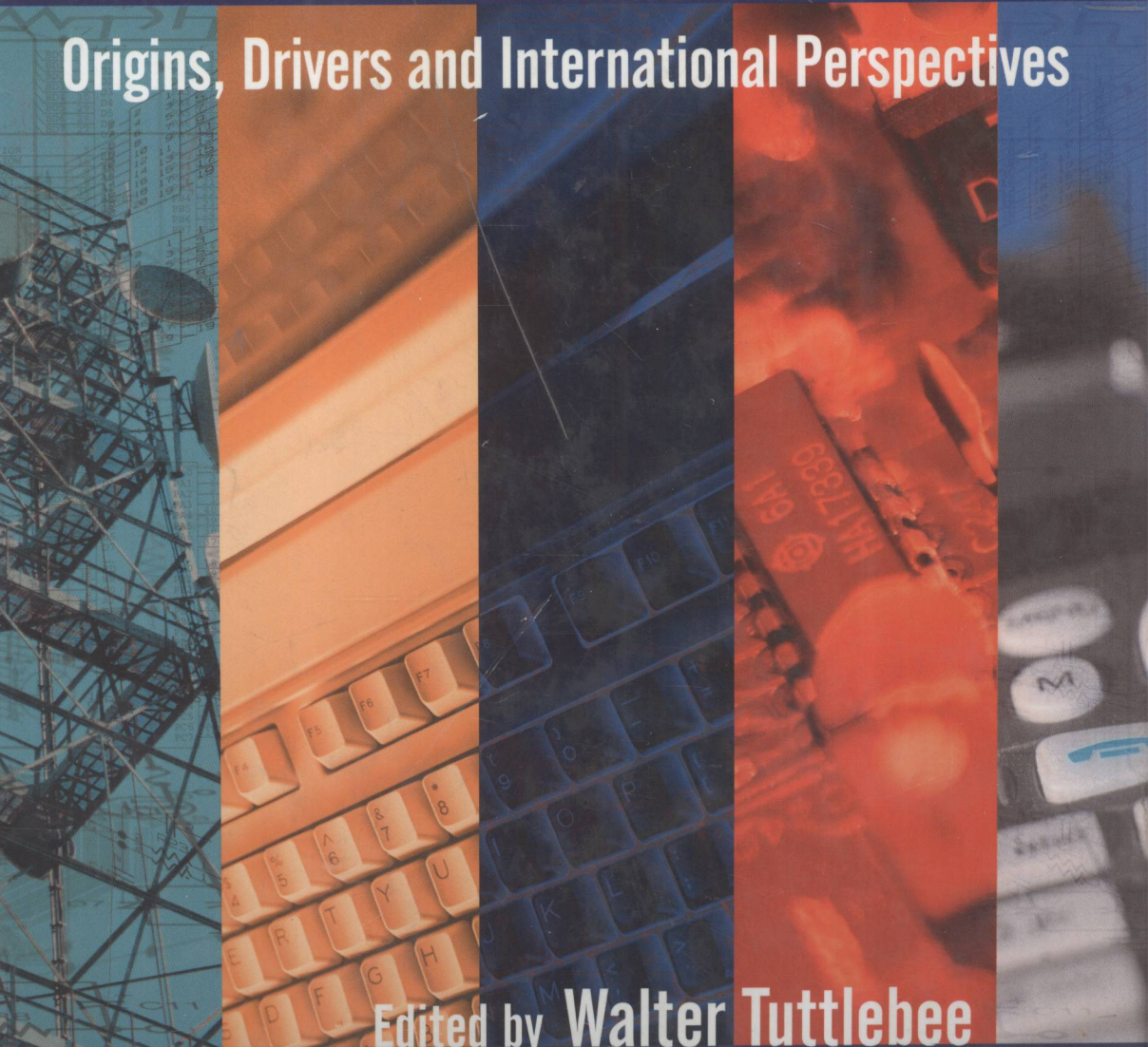


software defined radio

Origins, Drivers and International Perspectives



Edited by **Walter Tuttlebee**

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Virtual Centre of Excellence in Mobile & Personal Communications (Mobile VCE)



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Software Defined Radio

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Foreword

Few people in the profession are as qualified to create a new text on software defined radio (SDR) as Walter Tuttlebee. One of the first members of the global SDR Forum, Walter was also a pioneer in military research that laid the foundations of SDR at Roke Manor. His current role, heading the Mobile Virtual Center of Excellence, keeps him in the forefront of the research and transition to practice of this eclectic collection of technologies we call software radio.

This first volume brings together a world-class collection of authors whose perspectives will help each of us deal more effectively with the proliferation of SDR applications. First, Walter differentiates the ideal or ‘pure’ software radio (my personal favorite) from the many partial instantiations of that ideal, the ‘pragmatic’ software defined radios. His review of the technology drivers and scope of SDR sets the stage. Wayne Bonser, and Allan Margulies then round out the discussion of origins and drivers. Wayne has been one of the consistent voices in the US DoD arguing the benefits of military SDR since the early 1990s. Wayne’s partnership with DARPA on the SPEAKeasy programs and their predecessors is legendary. Similarly, Allan has been one of the unsung heroes of SDR, working tirelessly in the SDR Forum as the chair (and at times the only member) of the operations committee, and now the Forum’s first employee. Alan gives a first hand perspective of the Forum as it matures into a global meeting place and melting pot for the best of the best. This section more than sets the stage, it has superb insights into the interplay of business, regulatory, and technology interests with differing perspectives around the world.

Defining the real market opportunities will remain a work in progress for some time to come. The snapshot of views in Part II can give you a starting point for your own continuing analysis. Markets change rapidly, but authors from Motorola and Morphics give you the views of a representative well-established systems supplier and a successful start-up company on this important topic. Eduardo Ballesteros and Carlos Martínez then focus specifically on third generation commercial wireless opportunities.

The interplay of markets, regulatory, and technical perspectives on SDR continues in Part III as suppliers, researchers and regulators each discuss SDR from a regional perspective. Markus Dillinger and Didier Bourse survey the European scene from a hands-on perspective in ACTS and IST. Markus, Siemens in particular and Germany overall, continues to make substantial contributions to the emergence of SDR. German contributions range from Markus’ own work to that of colleagues Jondral (U. Karlsruhe), Fettweiss (T.U. Dresden), and Werner Mohr, (Siemens), and founding chair of the Wireless World Research Forum (WWRF), just to name a few of the more famous contributors – contributions from

some of these appear in Walter's next volume, *Software Defined Radio: Enabling Technologies*. Shinichiro ('Nick') Haruyama, similarly, captures the rapidly emerging Japanese program. The Japanese approach integrates the contributions of academic researchers and industrial giants in a way seldom matched around the world.

Pubudu Chandrasiri leads the transition of discussion from regional emergence to global standards. MExE was foreshadowed by the SDR Forum's groundbreaking work on secure download protocols. The MExE classmark system in some sense adapts the SDR Forum's approach to the needs of the commercial sector for simplicity and what one might call focused security (contrast with military INFOSEC). Global commercial standards supporting SDR make the regulatory tasks more manageable. Paul Bender of Germany and Stephen O'Fee of the UK then address regulatory tasks in the European Community head on, whilst Mike Grable offers an insider's view of the situation in the US. As of this writing, the US FCC had issued proposed rules intended to facilitate the reprogramming of radio functions in the field. The FCC's definition includes as an SDR any device that can change its emissions' RF frequency, bandwidth, or modulation by software. This ruling appropriately encompasses many multi-band and multi-mode wireless products in its scope.

Finally, Part IV looks at the early military and commercial markets. When I taught my first software radio course in Paris in 1996, I was most impressed with Ericsson, Nokia, and Rohde & Schwarz for the depth of understanding of these European leaders of the issues of this technology well before it emerged into the 3G migration plans several years later. I hesitate to say that the Europeans had a much better grasp of and practice with the benefits of high-end software standards and tools like Z.100, UML, and virtual machines, but they did. Few have more to offer from this head start than Ruediger Leschhorn of Rohde & Schwarz and David Hislop of RadioScape. Joined by their colleagues, these authors talk not just about the early products, but about the key abstractions – 'architectures' – that enable rapid, efficient reduction to practice. Their insights are absolutely essential for the rapid, affordable proliferation of SDR technology to military, civil, automotive, and broader commercial markets. The SDR Forum's current roadmap calls out the emergence of that cross-market synergism as a competitive advantage for the future. Those companies who best leverage that synergism should more rapidly transfer good ideas from one market segment, research group, or technology to others, reaping the benefits in market share and bottom line.

So let me conclude this foreword with enthusiastic congratulations to Walter and his world-class team for creating this timely tour de force of SDR. This text well complements other texts currently on the market. My own text, *Software Radio Architecture*, attempts to bridge the cultural divide between radio engineers and computer scientists. The IEEE text with Zoran Zvonar, *Software Radio Technologies: Selected Readings* collects those technical papers published in the IEEE until early 2001. Enrico Del Re's text *Software Radio* includes a strong collection of mostly European technical papers from his year 2000 Elba workshop. In addition, Jeff Reed (Virginia Tech, USA) and others are developing teaching texts for the English language corpus. And Walter's book – both volumes – fills a unique and critical niche in the panorama of software radio's on-going reduction to practice. Written by the world's experts, Walter included, you can't go wrong. Enjoy!

Dr. Joseph Mitola III
Consulting Scientist, MITRE Corporation

Abbreviations

2G	Second Generation Mobile Communications, e.g. GSM, TDMA
3G	3rd Generation Mobile Communications
3GPP	3rd Generation Partnership Project
A&T	Acquisition and Technology
A/D	Analogue to Digital Converter/Conversion
A2C2S	Army Aviation Command and Control System
ACTS	Advanced Communications Technologies and Services, part of the European 4th Framework Programme
ADARS	Adaptive Antenna Receive System
ADC	Analogue to Digital Converter/Conversion
ADI	Air Defense Initiative
ADM	Advanced Development Model
AFRL	Air Force Research Laboratory
AGC	Automatic Gain Control
ALC	Automatic Level Control
ALE	Automatic Link Establishment
AM	Amplitude Modulation
AMPS	American Mobile Phone System – a First Generation Analogue Mobile Phone Standard
AMTD	Affordability Manufacturability Technology Demonstration
AOC	Air Operations Center
API	Application Programming Interface
ARIB	Association of Radio Industries and Businesses, Japanese Industry Association
ARPK	Administrator Root Public Key
ARPU	Average Revenue Per User
ASIC	Application Specific Integrated Circuit
ASNR	Air Senior National Representatives
ASPEN	Advanced Signal Processing and Networking
ATC	Air Traffic Control
ATD	Advanced Technology Demonstration
ATDMA	EU supported collaborative TDMA research project under RACE
ATF	Advanced Tactical Fighter
AWE	Advanced Warfighter Experiment
BAA	Broad Area Announcement

BCS	Baseband Converter Subsystem
BCT	Brigade Combat Team
BIT	Built-In Test
BLOS	Beyond Line of Sight
Bluetooth	Short range wireless standard, intended for communication between cellphones and headsets/PCs
BMDO	Ballistic Missile Defense Organization
BRAN	Broadband Radio Access Network, an ETSI standard
BTI	Balanced Technology Initiative
C2	Command and Control
C3I	Command, Control, Communications and Intelligence
CA	Certification Authority
CAS	Close Air Support
CAST	EU supported collaborative SDR-related research project under IST
CC/PP	Composite Capability/Preference Profile
CCM	Certificate Configuration Message
CCSK	Cyclical Code Shift Keying
CDC	Control Data Corp.
CDMA	Code Division Multiple Access
CDMA-2000	3G evolution of the IS-95 digital cellular standard
CECOM	Communications & Electronics Command
CF	Core Framework
CLDC	Connected Limited Device Configuration
CLI	Common language Infrastructure
CNI	Communications, Navigation, and Identification
CNR	Combat Net Radio
CODIT	EU supported collaborative CDMA technology research projects under RACE
COMSEC	Communications Security
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off the Shelf
CP	Cryptographic Processor
cPCI	Compact PCI
CPU	Central Processing Unit
CPUAX	VHSIC Phase-II Chip
CRL	Communications Research Laboratory (Japan), also, Certificate Revocation List
CSI	Critical System Interconnect
CSP	Common Signal Processor
CTIA	Cellular Telephony Industry Association (USA)
CTR	Clock/Time/Reference
CVM [®]	Communication Virtual Machine
CVSD	Continuously Variable Slope Delta
CWAS	Commander's Situation Awareness Workstation
CYPRIS	Cryptographic Reduced Instruction Set [processor]
D/A	Digital to Analogue Converter/Conversion
DAB	Digital Audio Broadcasting
DAC	Digital to Analogue Converter/Conversion

DARO	Defense Airborne Reconnaissance Office
DARPA	Defense Research Projects Agency
DASD	Deputy Assistant Secretary of Defense
DCA	Defense Communications Agency
DDR&E	Director Defense Research and Engineering
DISA	Defense Information Systems Agency
DoD	Department of Defense
DRE xyz	Texas Instruments DSP DAB chip
DRiVE	EU supported collaborative SDR-related research Programme under IST
DRM	Digital Rights Management
DSP	Digital Signal Processing/Processor
DSSS	Direct Sequence Spread Spectrum
DTL	Diode-Transistor-Logic
DTMF	Dual Tone Multi Frequency
DUSD	Deputy Under Secretary of Defense
EAM	Emergency Action Message
ECCM	Electronic Counter Counter Measure
ECIT	Enhanced Communications Interface Terminal
ECM	Electronic Countermeasure
ECMA	European Computer Manufacturers' Association
EDM	Engineering Development Model
EEI	External Environment Interface
ELF	Extremely Low Frequency
ELINT	Electronic Intelligence
EMP	Electromagnetic Pulse
EPM	Electronic Protection Measures
EPROM	Erasable Programmable Read-Only Memory
ERM	Entity Reference Model
ESC	Electronic Systems Center
ESPRIT	Early European collaborative research in Information Technology
ESU	Executive Service Unit
ETSI	European Telecommunications Standards Institute
FAA	Federal Aviation Administration
FDDI	Fiber Distributed Data Interface
FDL	Fighter Data Link
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FH	Frequency Hopping
FIRST	EU supported collaborative SDR-related research Project under RACE
FM3TR	Future Multiband Multiwaveform Modular Tactical Radio
FPGA	Field Programmable Gate Array
FRAMES	EU supported collaborative research project under ACTS which played a major role in defining the 3G air interface, UTRA
FSK	Frequency Shift Keying
GBP®	Generic Baseband Processor
GloMo	Global Mobile

GPPE	General Purpose Processing Element
GPRS	Generalized Packet Radio Service, evolution of GSM
GSM	Global System for Mobile – TDMA-based Second Generation Mobile Phone Standard
GWEN	Ground-Wave Emergency Network
HaveQuick	Secure defense radio system
HF	High Frequency
HIPERLAN	ETSI wireless access/WLAN standard
HMI	Human Machine Interface
HNM	Host Network Manager
HP	Hewlett Packard
HPIB	Hewlett Packard Interface Bus
HRM	Home Reconfiguration Manager
HTTP	Hypertext Transfer Protocol
I&CP	International and Commercial Programs
I/O	Input/Output
IBMS	Integrated Broadband Mobile System, research Programme under the German national Programme
ICNIA	Integrated Communications Navigation Identification Avionics
IDL	Interface Definition Language
IEEE	Institute of Electrical and Electronics Engineers
IEICE	The Institute of Electronics, Information, and Communication Engineers, Japan
IF	Intermediate Frequency
IFF	Identification Friend or Foe
ILS	Integrated Logistics Support
IM/S	Independent Mark Space
i-Mode	Interactive cellular Internet service in Japan
IMSI	International Mobile Subscriber Identity
IMT-2000	International Mobile Telecommunications standard, 3G standards framework of the ITU
INFOSEC	Information Security
IP	Internet Protocol, also, Intellectual Property
IPT	Integrated Product Team
IrDA	Infrared data communication standard
IS-136	TDMA based 2nd Generation Digital Mobile Phone Standard
IS-95	CDMA-based 2nd Generation Digital Mobile Phone Standard
ISC	Intelligent System Controller
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
ISS	Interference Suppression Subsystem
IST	Information Society Technologies, part of the European 5th Framework Programme
ISTAG	IST Advisory Group
ITU	International Telecommunications Union
J2EE	Java 2 Enterprise Edition
J2ME	Java 2 Micro Edition
J2SE	Java 2 Standard Edition
JAR	Java Archive file format

JARECO	Jam Resistant Communications
JCIT	Joint Combat Information Terminal
JCP	Java Community Process
JDL	Joint Director of Laboratories
JROC	Joint Requirements Oversight Council
JTAG	Joint Test Action Group [IEEE standard 1149.1]
JTIDS	Joint Tactical Information Distribution System
JTRS	Joint Tactical Radio System
JVM	Java Virtual Machine
JWID	Joint Warrior Interoperability Demonstration
KP	Key Processor
KVM	Kilobyte Virtual Machine
LAN	Local Area Network
LCC	Life Cycle Cost
LF	Low Frequency
LLPE	Low Latency Processing Element
LOS	Line of Sight
LPI	Low Probability of Intercept
LPI/D	Low Probability of Intercept and Detection
LRIP	Low Rate Initial Production
LRM	Line Replaceable Module
LRU	Line Replaceable Unit
LTTP	Long Term Technology Program
MAG	Market Aspects Group (of the UMTS Forum)
MATT	Multi-mission Advanced Tactical Terminal
MBMMR	Multiband Multimode Radio
MCM	Multi-Chip-Module
MEDIAN	EU supported collaborative research project under RACE
MEECN	Minimum Essential Emergency Communications Network
MEMS	MicroElectroMechanical-System
MExE	Mobile Execution Environment
MFBARS	Multifunction, Multiband, Airborne Radio System
MIDP	Mobile Information Device Profile
MIDS	Multifunction Information Distribution System
MIPS	Mega Instructions Per Second
MMAC	Multimedia Mobile Access Communication Systems
MMI	Man Machine Interface
MMITS	Modular Multifunction Information Transfer System
MNS	Mission Need Statement
MOBIVAS	EU supported collaborative SDR-related research project under IST
MONET	EU supported collaborative mobile network research project under RACE
MPHPT	Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan
MPT	Ministry of Posts and Telecommunications (Japan), now part of the MPHPT
MRPK	Manufacturer Root Public Key
MSE	MExE Service Environment
MSK	Minimal Shift Keying

NDI	Non-Developmental Item
NRaD	Naval Research and Development
NRL	Naval Research Laboratory
NSA	National Security Agency
OASD	Office of the Assistant Secretary of Defense
OCSP	Online Certificate Status Protocol
OEM	Original Equipment Manufacturer
OMG	Object Management Group
ORB	Object Request Broker
ORD	Operations Requirement Document
ORPK	Operator Root Public Key
OSD	Office of the Secretary of Defense
OSI	Open Standards Interconnect, standards body and philosophy
OS-JTF	Open System – Joint Task Force
OSP	Online Service Provider
OTA	Over The Air
P25	Standard used for North American Public Safety Communications
P3I	Pre-Planned Product Improvement
PABX	Private branch exchange – an on-site telecommunications switch
PASTORAL	EU supported collaborative SDR-related research project under IST
PCI	Personal Computer Interface
PCMCIA	Personal Computer Memory Card International Association
PDC	Personal Digital Cellular standard, Japan
PDUSD	Principal Deputy Under Secretary of Defense
PKI	Public Key Infrastructure
PKCS	Public Key Cryptographic Standard
PLMN	Public Land Mobile (telecommunications) Network
POS	Point of Sale
POSIX	Portable Operating System Interface
PPS	Preprocessor Subsystem
PRM	Proxy Reconfiguration Manager
PRN	Packet Radio Network
PROMURA	EU supported collaborative research project under RACE
PSTN	Public Service Telecommunications Network
QoS	Quality of Service
R&D	Research and Development
RACE	Research into Advanced Communications technologies in Europe, part of the European 3rd Framework Programme
RADC	Rome Air Development Center
RAP	Radio Access Point
RDEC	Research, Development and Engineering Center
RDF	Resource Description Framework
REN	Range Extension Node
RF	Radio Frequency
RFP	Request For Proposal
RNS	Residue Number System

ROM	Read Only Memory, also, Rough Order of Magnitude
RPK	Root Public Key
RRC	Rome Research Corporation
RTL	Resistor-Transistor-Logic
RTOS	Real Time Operating System
S&T	Science and Technology
SATURN	Secure defense radio system, also an EU supported collaborative SDR-related research Programme under IST
SCA	Software Communications Architecture
SCVP	Simple Certificate Verification Protocol
SDI	Strategic Defense Initiative
SDL	Specification and Definition Language
SDR	Software Defined Radio
SEM-E	Standard Electronic Module format-E
SHF	Super High Frequency
SIM	SPEAKeasy INFOSEC Module
SIM	Subscriber Identity Module
SINUS	EU supported collaborative research Programme under RACE
SIP	Silicon Intellectual Property
SLATS	EU supported collaborative research project under RACE
SLFCS	Survivable Low Frequency Communications System
SMS	Short Message Service
SoC	System on a Chip
SODERA	EU supported collaborative SDR-related research Programme under IST
SOO	Statement Of Objectives
SOPRANO	Software Programmable and Hardware Reconfigurable Architecture for Network (software radio testbed of Sony Computer Science Laboratories, Inc.)
SoRDS	Software Radio Development System (software radio testbed of AFRL)
SORT	EU supported collaborative research project under RACE
SPO	Special Program Office
SRC	Syracuse Research Corporation
SRM	Serving Reconfiguration Manager
SSL	Secure Sockets Layer
STAJ	Secure Tactical Anti-Jam
STANAG	Standard NATO Agreement
SUNBEAM	EU supported collaborative research project under RACE
SWAP	Size, Weight, and Power
SwRM	Software Reference Model
TACP	Tactical Air Control Party
TACS	Total Access Communications System (UK analogue cellular standard based on AMPS)
TADIX-B	Tactical Data Information Exchange System Broadcast
TAJPSP	Tactical Anti-Jam Programmable Signal Processor
TCDL	Tactical Common Data Link
TCS	Terminal Control System
TCTU	Tactical Communications Terminal Unit

TDMA	Time Division Multiple Access
TETRA	Trans European Trunked Radio – Digital PMR Standard
TF	Task Force
TIBS	Tactical Information Broadcast Service
TOC	Tactical Operations Center
TRANSEC	Transmission Security
TRAP	Tactical Receive Applications
TRE	Tactical Receive Equipment
TRUST	European research project IST-1999-12070 ‘Transparently Reconfigurable Ubiquitous Terminal’
TTCN	Tree and Tabular Combined Notation
TTP	Trusted Third Party
UCD	Use Case Diagram
UHF	Ultra High Frequency
UML	Unified Modeling Language
UMTS	Universal Mobile Telecommunications Service
U-NII	Unlicensed National Information Infrastructure
URL	Uniform Resource Locator
USAF	United States Air Force
USD	Under Secretary of Defense
USIM	Universal Subscriber Identity Module
USMC	United States Marine Corp
USN	United States Navy
UTRA	UMTS Terrestrial Air Interface
UWC-136	3G evolution of the IS-136 digital cellular standard
VAS	Value-Added Service
VCO	Voltage Controlled Oscillator
VCOS	VHSIC Chip on Silicon
VDL	VHF Digital Link
VHDL	VHSIC Hardware Description Language
VHF	Very High Frequency
VHSIC	Very High Speed Integrated Circuit
VIADAB®	Versatile Information Architecture for DAB
VLf	Very Low Frequency
VLSI	Very Large Scale Integration
VME	Versa Module EuroCard
W3C	World Wide Web Consortium
WAN	Wide Area Network
WAP	Wireless Application Protocol
WARC	World Administrative Radio Conference
WCDMA	Wideband Code Division Multiple Access
WDE	Waveform Definition Environment
WDL	Waveform Definition Language
WGS	Waveform Generator Subsystem
WINDFLEX	EU supported collaborative SDR-related research project under IST
WML	Wireless Markup Language