Radio Spectrum Policy in Europe: “Shared use of spectrum” as a new paradigm for spectrum management

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* Disclaimer: the views expressed are those of the author and cannot be regarded as stating an official position of the European Commission.
Scope of presentation

1. Radio spectrum policy in the EU
2. Three trends towards rethinking spectrum management
3. Demand: emerging spectrum usage profiles and applications
5. Responsibilities and challenges for implementing collective use
6. Cost / benefits of shared use?
7. On-going activities and state of play in the EU
8. Conclusions

References
Section 1: Radio spectrum policy in the EU
Europe’s spectrum policy in context

- EU: ~500 million inhabitants = consumers
- EU ICT turnover: bn€ 660
- Radio related electronic communications services (ECS): >250 bn € or 2.2% of EU GDP
- ICT sector contributes to 20% of overall GDP growth and to ~30% of the productivity growth.
- Radio sector is an important growth factor and offers a significant opportunity for recovery
- Radio applications are pervasive to all areas of modern information society and contribute to quality of life and efficiency
Europe’s spectrum policy in context

Region with *individual* countries …

• own and regulate spectrum individually
• different spectrum legacies
• issue spectrum national usage rights
• national conditions:
  economic development; cultural background;
  geography / demography; wireless service
  needs; markets; etc

... but European Union as *political* and *economic* entity

• integrated economies (growth, competitiveness, jobs,...); internal market →
• enabling frame:
  • coordination of spectrum policy
  • (radio) equipment regulation

Towards the New Era for Radio Usage including White Spaces
Tokyo, 1 March 2010
Paradigm shift: spectrum management $\rightarrow$ spectrum policy

**Spectrum administration**

- spectrum policy
- spectrum administration
- users
- "distribution" of spectrum
- managing interference
- Laws of physics

**Policy objectives**

- Active use of spectrum as a means:
  - a key ingredient for economic activities
  - a factor impacting on:
    - innovation
    - competition
    - competitiveness

- EU?
- national?
- Regulator?

**traditional concept:**
*technical spectrum management:*
- technical efficiency
- containing interference

**new concept:**
*spectrum policy*
- socio-economic and cultural efficiency
Spectrum policy at EU level: organisation

- Commission + European Parliament + Council → EU Law

- Spectrum policy strategy

- Commission + Member States: harmonisation measures → EU law

- EU Member States → national law, but EU frame (Commission initiative for coordination)

- Usage conditions (allocation)

- Access to radio spectrum (assignment)

- Radio Spectrum Policy Group RSPG

- Radio Spectrum Committee RSC

- CEPT

- Market players + Member States + Research community

Legal basis: Radio Spectrum Decision 676/2002/EC
Equipment regulation at EU level: organisation

Commission + European Parliament + Council → EU Law

standardisation policy

Commission + Member States: Harmonised Standards → EU law

Equipment manufacturers: ensuring compliance
EU Member States: usage surveillance at national level

compliance standards

compliance declaration

Legal basis:
R&TTE Directive 5/1999/EC

Market players + Member States + Research community

TCAM

ETSI

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Main stream policy lines of EU spectrum policy

Maximising socio-economic /cultural potential of spectrum

- balancing coordination at EU level vs national flexibility
- empowering spectrum user (less “command and control”)
- no dogmatic approach, mix of management paradigms:
  market based assignment for exclusive usage rights / license exempt approach non-exclusive rights / “command & control”
- facilitating access to spectrum resources
- promoting efficient spectrum usage
- wireless access policy (“WAPECS”): technology and service neutrality for spectrum usage (electronic communications services)
- Synergy of research efforts and spectrum policy
Section 2:
Three trends towards rethinking spectrum management
Rethinking spectrum management?

3 key drivers tentatively identified:

- “surging demand for spectrum creates **scarcity**”
- “technological progress changes the way we use and manage spectrum”
- “**new spectrum usages** changes demand for spectrum”
“Scarcity”

- **Spectrum “quality”** varies according frequencies
- **Key “physical factors” vs. user demand:**
  - transmission bandwidth
  - penetration capability
  - coverage range
- **Key challenge:**
  - definition **optimum “cell architecture”** per usage
  - **making spectrum available**
    (key issue: legacy spectrum usage rights)
- **Today’s perception**
  - scarcity < 1 GHz
  - higher frequencies exploitable?
“technological trends”

- usage higher spectrum range becomes increasingly technically feasible

- from “dumb” to intelligent receivers improved interference resistance technically feasible

- major (disruptive ?) technical break through: adaptive radio

  - possibility of sharing usage between different users
  - possibility for individual right holder to optimise the usage of spectrum assigned to him
adaptive techniques

Software defined radio (SDR)

**Radio controllable by software → flexibility**

A radio transmitter and/or receiver employing a technology that allows RF operating parameters including, but not limited to, frequency range, modulation type, or output power to be set or altered by software (…)

Cognitive radio system (CR)

**Control strategy through sensing → “intelligence”**

A radio system employing technology that allows the system to obtain knowledge of its operational and geographical environment, established policies and its internal state; to dynamically and autonomously adjust its operational parameters; and to learn from the results obtained.

**ITU-R Study Group 1**
Section 3:

Demand: emerging usage profiles and application candidates
Trends in new spectrum usage patterns

• “global” use → “local” → “personal” use

- **WAN**
  - high-power
  - wide coverage
  - infrastructure shared by many users

- **LAN**
  - low-power
  - small coverage
  - infrastructure shared by several users

- **PAN**
  - low-power
  - small coverage
  - individual / personal use
Trends in new spectrum usage patterns

- nomadic / occasional use

- personal equipment on the move

- backbone network / "cloud"

- personal data / service environment
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Trends in new spectrum usage patterns

- “mass” applications
- “democratisation” of spectrum access

**Trend**

- Many new “individual” applications emerging
- Demand for quick set up of communication infrastructure
- Innovative momentum dependent on spectrum availability and easy access

**Impact**

- Demand for sufficient spectrum
- Flexible spectrum usage needed
- Easy spectrum access (licensing)
Trends in new spectrum usage patterns

- Quality of service (QoS) depends on application, but:

  **trend**

  - New “individual” applications allow for compromises on *quality in transmission* reliability without endangering significantly the *quality of service*

  **impact**

  - higher interference tolerance
  - opens up “polluted” spectrum bands for new usages
Trends in new spectrum usage patterns

- Dynamic economies of spectrum usage

  **trend**
  - a single application is characterised by demand of spectrum varying over time
  - Examples of variables: bandwidth, transmission QoS, usage time and range, price of spectrum access vs. business case revenues

  **impact**
  - More efficient spectrum usage in technical and economic terms possible
  - Flexible reuse on spectrum feasible reduces scarcity
Examples of “new” usages

- home automation
- local wireless extension of broadband access
- local media streaming
- communications needs for towns / local communities
- transport applications
- remote metering, energy consumption surveillance
- security applications, remote surveillance
- medical telemetry, social alarms
- “internet of things”
- mobile communications (reconfigurable networks)
Section 4: Spectrum sharing: “Collective use of spectrum”
Shared use of spectrum: potential benefits and models

- **Innovation driver**
  - shared use of spectrum stimulates development of technologies for advanced interference mitigation
  - dynamic use of spectrum facilitates adaptive network deployment
- **Sharing of spectrum serves policy objectives**
  - new and diverse services to the citizen;
  - overcoming digital divide
  - enabler for sectorial policy objectives (environment, transport, ...)
  - wireless communications benefit the ICT sector, hence represents a significant growth driver
  - flexible usage conditions lowers barrier to small scale business cases: potential benefits to SMEs, service innovators, etc.
- **Increasing spectrum supply through shared use:**
  - drives spectrum prices down
  - lowering the barrier to access spectrum increases competition
Shared use of spectrum: potential benefits and models

shared spectrum usage

collective usage of spectrum (CUS)

- unknown number of users
- dynamic usage

planned coexistence of spectrum usages

- known number of users
- static usage
“Collective use of spectrum”

An attempt to clarify “language” and to set the context:

“Collective Use of Spectrum allows an undetermined number of independent users and / or devices to access spectrum in the same range of frequencies at the same time and in a particular geographic area under a well-defined set of conditions”

RSPG Report RSGP08-244, November 2008
“Collective use of spectrum”
Sharing models

**collective usage of spectrum (CUS)**

- unknown / varying number of users

<table>
<thead>
<tr>
<th>“ISM band” model</th>
<th>“white space” model</th>
<th>“access right arbitration”</th>
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</thead>
<tbody>
<tr>
<td>• band availability: static (specs to protect legacy users)</td>
<td>• band availability <strong>dynamic</strong> “vertical sharing” (specs to ensure priority use for legacy users)</td>
<td>• access rights <strong>dynamically</strong> attributed on demand: “horizontal” or “vertical sharing”</td>
</tr>
<tr>
<td>• all users compete dynamically for access: “horizontal sharing” (specs to determine sharing conditions)</td>
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<td>• <strong>common technical usage frame</strong></td>
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<td></td>
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<td>• <strong>arbitration rules</strong></td>
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“Collective use of spectrum”: Techniques to avoid interference

Interference mitigation remains the central issue:

• Setting **static technical usage parameters**:
  • Power limits, indoor constraint, modulation / coding specs etc.
  guaranteeing a determined static level on non-interference
  → rigid, suboptimal approach
  → simple / cheap radio equipment

• Using **adaptive techniques parameters**:
  • allowing spectrum usage under less restrictive parameters, but
    imposing to take the actual spectrum occupancy into account.
  → increased spectrum usage efficiency through dynamic approach
  → costs of more sophisticated radio equipment
Collective use of spectrum: The role of CR techniques

- unknown varying number of users

"ISM band" model

- surviving in a crowded environment
- politeness rules

"white space" model

- determine whether usage of spectrum is permitted

"usage arbitration"

- acquire "suitable" usage right (amount / quality / price of spectrum)
Collective use of spectrum: usage rights / protection

- unknown number of users
- dynamic usage

“ISM band”
- license exempt! (general authorisation)

“white space”
- license exempt? (general authorisation)

“usage arbitration”
- individual license!
- market based assignment
- private management

**protection** variable depending on usage right
“Collective usage of spectrum”
Radio spectrum available matching needs?

• “ISM band” model
  - exists and has offered good results
  - spectrum is available under this model
  - test bed for simple forms of CR

• “white space” model
  - the “next step”, driven by scarcity
  - costs? which bands?

• “arbitration of exclusive rights”
  - futuristic concept, new approach of sharing
  - applicable to bands which apply individual rights
  - not used so far, intensive research
  - “concept driver”: optimise networks using dynamic spectrum usage approaches

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“White Spaces” approach untested

• “white spaces” opportunity
  • potentially offering new resources of “prime spectrum”

• candidate bands?
  • demand: the “right” spectrum band
  • > call for “low” frequencies: covering local area, good penetration
    > call for “high” frequencies /offering aggregated spectrum blocks: high transmission bandwidth
  • supply: bands with “white space potential”
    > broadcasting
    > defence
“White Spaces” approach untested

- alternative solutions to “white spaces” exist:
  - “low” frequency ISM bands: 2.4 GHz band very successful
  - UWB technology so far not commercially very widely used
  - other alternative access modes:
    > power line
    > exploiting high frequencies (e.g. 60 GHz)
    > mobile cellular networks (machine to machine communication)
    > femto cells to bridge the gap to fixed broad band access
      (no “fresh” spectrum needed, convergence fixed/mobile)

- challenges of regulatory, technological nature

- implementation costs vs. benefits?
Section 5:
Responsibilities and challenges for implementing collective use
“Collective usage of spectrum” responsibilities involved

- **Regulators:**
  - selecting candidate bands and determining sharing model
  - defining usage conditions
  - regulating equipment (receiver characteristics ?)
  - overall responsibility for “predictable interference environment”
  - monitoring actual usage of spectrum and maintaining information
  - Defining liabilities
  - ensuring equitable access to radio resources

- **Equipment manufacturers:**
  - developing interference resistant receivers
  - developing software defined radio
  - designing cognitive radio capable equipment as solution to satisfy usage conditions set by regulation
  - standardisation effort
  - equipment conformance

- **Spectrum users:**
  - adhering to static parameters and to sharing protocol discipline
Challenges to exploit “ISM bands”

• **Regulatory challenges**
  - identifying suitable ISM bands (across the whole spectrum range; according to demand, new usages; global coordination)
  - setting least constraining general usage parameters (TN, SN)
  - Making bands effectively available
    - legal certainty over usage rights,
    - defining new interference models
    - protection of legacy usages
    - defining liabilities
  - ensuring conformance compliance of equipment, enforcement
  - usage monitoring

• **Technology challenges**
  - interference resistance receivers
  - standardisation of interference mitigation techniques (CR such as “listen before talk” LBT, “detect and avoid” DAA)
  - reducing cost of equipment
Challenges to exploit “white spaces”

• Identifying white space bands
  • what is the definition of “unused” spectrum?
    → How much spectrum becomes available through white spaces?
  • difficulty to define the usage of spectrum to be protected (frequency / geography / time space)
  • anticipation of future development of legacy usages to be protected

• Linking CR technology to permitted usage conditions
  • today’s approach: principle of “zero tolerance” as for interference of white space secondary user on legacy user
  • new approach: mutually tolerated interference?
  • new challenge: trust in CR and its performance determine operational radio parameters and the format of usage right.
  • liability
Challenges to exploit “white spaces”
CR specific issues

• CR technology: **how to sense the radio environment?**

  • direct sensing of environment
    > the hidden node problem (communication between CR radios)
    > setting levels of emission signals to be detected
    > signature of signal to be protected
    > periodicity of sensing

  • pilot channel / sensing networks approach:
    > spectrum for the pilot?
    > where does the information of the pilot come from?
    > who “owns” and runs the pilot? Who bears the costs?
    > standardisation of the pilot (cross border?)

• “geolocation”
  > defining the database structure and information it contains
  > updating the database
  > who “owns” and operates the database? Who bears the costs?
  > security issues
Challenges to implement “usage right arbitration” model

- **potential supply:** “spot spectrum environment” definition
  - amount of spectrum / usage area / availability over time / interference to be tolerated / max permitted interference generation / applicable transmission parameters / spectrum price / etc.

- **technology**
  - monitoring spectrum usage on-line
  - making information on available spectrum environment available (geolocation ? pilot ?)
  - organising and realising **on-line arbitration** (e.g. spot or leasing market, peer to peer or band manager, etc.)
  - standardisation of procedures
Challenges to implement “usage right arbitration” model

- **missing elements**
  - availability of CR capable equipment
  - monitoring spectrum usage
  - running real-time spectrum arbitration

- **regulatory challenges**
  - new approach to usage rights assignment (on-line trading)
  - spectrum pooling concepts
  - defining usage rights in terms of interference
  - setting rules for fair access to spectrum, competition aspects
  - ensuring conformance of CR equipment
  - defining liabilities
  - security
Section 6: cost / benefits of collective use?
Cost / benefits: a tentative assessment

- "ISM model" in many cases viable (CR already introduced)
  - RLAN in 2.4 and 5 GHz: LBT technology for shared use, incl. protection of radar application
  - UWB in 3.5-9.5 GHz: DAA technique
  - SRR UWB in 24 GHz: geolocation based switch off (radio astronomy sites)

- More sophisticated shared use so far unproven to deliver viable business models
  - technical stable and standardised CR solutions still under progress for "white spaces", only beginning for "arbitration of usage rights" model
  - cost of sophisticated CR equipment not tested
  - time to market uncertain
  - uncertainty over amount of "unused spectrum" and over regulatory environment
Cost / benefits of “shared usage” approach
a tentative assessment

- Drivers to new forms of collective use such as “white spaces” and “arbitration of rights”:
  - technological experience driven by need to optimise networks, (allow for a more efficient use of the rights holder’s own spectrum asset)
  - push for using lower frequencies usage focuses attention on using “white spaces” in broadcasting bands
  - other opportunities for white spaces to be explored: defence spectrum
Section 7: On-going activities and state of play in the EU
EU spectrum policy: building blocks related to collective use of spectrum

- General policy initiatives
- Regulatory measures
- Research and Development
- Standardisation
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<th>issue</th>
<th>RSPG</th>
<th>Commission</th>
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<td>Secondary trading</td>
<td>usage rights secondary trading</td>
<td>Opinion</td>
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<td>Collective use of spectrum</td>
<td>applications, needs</td>
<td>Opinion</td>
<td>Study</td>
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<td>flexible use of spectrum (TN,SN)</td>
<td>Opinion</td>
<td>Communication; regul. Framework ECS</td>
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<td>Interference models</td>
<td>definition of interference</td>
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<td>Study</td>
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<td>Digital Switchover / Digital Dividend</td>
<td>spectrum aspects, reorganisation of UHF band, white spaces</td>
<td>2 Opinions on Digital Dividend</td>
<td>Communication RRC06; WRC-07 Communication; Communication Dig.Div.; Digital Dividend Roadmap</td>
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<td>Broadband wireless</td>
<td>spectrum needs for broadband</td>
<td>Report</td>
<td>I2010 → European Digital Agenda, broadband strategy</td>
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<tr>
<td>Cognitive radio</td>
<td>analysing issues, state of play, perspectives</td>
<td>Report</td>
<td></td>
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<tr>
<td>WRC-11</td>
<td>AI 1.19 on CR</td>
<td>Opinion</td>
<td>[WRC-11 Communication]</td>
</tr>
</tbody>
</table>
EU spectrum policy: RSPG report on collective use of spectrum


• expects increasing importance of the collective use (CUS) model, but the concrete demand difficult to predict; the CUS model seen as particularly suited for “smaller users”, mainly short range (but not only)

• spectrum should be made available in whole range; emphasis of underused opportunities in high spectrum bands; need to be pro-active on availability of CUS spectrum (e.g. 40 GHz, experimental spectrum)

• “markers” for deciding of suitability for CUS model: “range” / “power level” / “specific spectrum band needed” / “type of usage”

• suggests to group different groups of usages following CUS, to ease the issue of mixing very different usage in a same band.

• suggests to explore the possibility of setting a power threshold below which devices can operate at any frequency on a CUS basis

• dynamic spectrum access becoming more important, needs to be supported by suitable regulation; impact of cognitive radio acknowledged

• emphasises need to allocate spectrum flexibly for exclusive usage (incl. overcoming legacy constraints) for the usage based on the CUS model

Complementary: Study on Collective Use 2006
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EU spectrum policy: RSPG report on cognitive radio

RSPG CR Report

- Identifies cognitive radio as key element to move from static to dynamic spectrum management
- Clarifies terminology and components of CR
- Notes usage of CR for sharing but also optimising networks and its spectrum consumption
- Emphasises that CR is not confined to license exempt spectrum usage, but can benefit also in case of exclusive right usage arbitration
- Analyses the usage of CR in the case of white spaces and identifies issues to solve
- Emphasises need for a harmonised approach to CR

To be followed up by an RSPG Opinion identifying necessary regulatory measures to be taken to facilitate the introduction of CR (delivery end 2010)
Digital Dividend / White Spaces

The digital dividend roadmap (October 2009)

• Immediate actions:
  > accelerating the switch-off date for all Member States: 1/1/2012
    (note: to date: 6 MS have already switched off, 26 out of 27 will
    switch off in the course of 2012)
  > mandatory usage conditions for wireless broadband services
    in the 790-862MHz (“800MHz band”), no date for making available
    (note: Austria, Czech Republic, Finland, France, Germany, Spain,
    Sweden, Netherlands and UK already on track for assigning this band)

• Actions to be proposed (Radio Spectrum Policy Programme)
  > mandatory availability of the 790-862 MHz band
  > minimum efficiency level for the use of the digital dividend in the EU
  > establishing common position for coordination with third countries

• Long term actions to improve the usage of the digital dividend
  > preparing for next generation transmission or compression
  > ensuring minimum receiver interference resistance
  > frequency agile wireless communication technology development
  > migration of wireless microphones
  > usage of white spaces
Digital Dividend / White Spaces

- **Amount of white spaces varies in MSs**
  - example UK estimate: 50% of all locations offer 100-150 MHz white space
  - increased usage of bands <790MHz by broadcasting; also: more channels, HDTV, 3D TV; higher packing of channels
  - spectrum available through White spaces tend to shrink

- **Services to be protected when opening white space usage:**
  - broadcasting
  - PMSE equipment ("wireless microphones")
  - other usages (in certain Member States)

- **Commission initiatives to be expected:**
  - support technical studies (in cooperation with CEPT)
  - examine socio-economics
  - plan for PMSE equipment

- **Member States initiatives:**
  - UK public consultation on CR applied to UHF white spaces
  - experimental spectrum in IRL
  - trials in FIN, etc.
CEPT work on White Spaces

- Investigating cognitive radio for white spaces in UHF:
  - CEPT reports 24 (June 2008) recommends
    > white space usage on non-protected non interfering basis
    > to undertake further studies (activities on-going in ECC SE43)
  - ECC Spectrum Engineering Group (SE43):
    > geolocation method: database specifications
    > sensing: performance specification
  - report due mid 2010

- Related work:
  - Investigating candidate bands for CR based usage
    ECC Frequency management Group (FM)
  - Preparing for WRC-11 (agenda item 1.19):
    ECC Conference Preparatory Group (CPG)
Open regulatory questions in the EU

- **Interference models:**
  - present regulation: interference defined in terms of avoiding “harmful interference”, i.e. a worst case scenario
  - alternative: interference defined through impact on spectrum users, i.e. through tolerable interference
  - possible new approach: usage rights defined by applicable interference conditions
  - option for spectrum users to negotiate usage agreements bilaterally setting individual mutually agreed interference constraints
  - Commission Study “Interference Models” undertaken in 2008

- **Receiver specifications**
  - regulatory option of setting receiver parameters? Other incentives?

- **Equipment regulation**
  - European system of self-compliance may raise issues on CR context
  - Formal certification of CR equipment (incl. software) needed
## EU spectrum policy: Harmonisation measures

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<th>area</th>
<th>application</th>
<th>CR ?</th>
<th>assignment mode</th>
</tr>
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<tbody>
<tr>
<td>Short range devices</td>
<td>large variety of applications</td>
<td>(x)</td>
<td>unlicensed</td>
</tr>
<tr>
<td>RFID</td>
<td>object tagging</td>
<td>(x)</td>
<td>unlicensed</td>
</tr>
<tr>
<td>SRR 24 GHz and 79 GHz ITS</td>
<td>road safety</td>
<td>x</td>
<td>unlicensed</td>
</tr>
<tr>
<td>Ultra wide band (UWB)</td>
<td>high bit-rate communication; specific applications</td>
<td>x</td>
<td>unlicensed</td>
</tr>
<tr>
<td>5GHz R-LAN</td>
<td>ECS</td>
<td>x</td>
<td>unlicensed</td>
</tr>
<tr>
<td>Mobile communications on planes and vessels</td>
<td>ECS</td>
<td>x</td>
<td>licensed + unlicensed</td>
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Regulatory action on short range devices (SRD)

- CEPT: traditionally developing consensus on voluntary common technical parameters for a number of bands (SRD MG producing ECR REC70-03)
- European Commission SRD Decision (2006): legally binding harmonised usage parameters, annual updates
- Approach:
  - least constraining usage parameters (technological and service neutral approach; power emission limits, duty cycles, possibility for channel aggregation, etc.)
  - interference mitigation techniques base on simple CR used in certain bands (mitigation \textit{performance} objective by reference to standards where available)
  - investigate approach to introduce generic emission thresholds below which transmission would be unregulated
  - increasing number of bands harmonised at EU level
  - link to standardisation (compliance)
UWB Regulation

- regulation based on technical studies undertaken by CEPT

- initial UWB regulation (2007)
  - indoor - short range/high data rate type of applications
  - Spectrum mask for usable range between 3.5 -9.5 GHz
  - Imposing “detect and avoid” (simple CR) in certain parts of the band

- extended UWB regulation (2009)
  - extend to use in ‘road and rail’ vehicles
  - special conditions for wall penetrating radar
Regulation for mobile communications on planes and ships

- Regulation based on technical studies undertaken by CEPT

- **Mobile communications on airplanes**
  - Shared spectrum 1800 MHz
  - Issue is separation of terrestrial from on-board usage
  - On-board base station:
    > geolocation”: switching off depending on altitude
    > controlling mobile terminals on board: noise floor to hide terrestrial networks

- **Mobile communications on vessels**
  - Shared spectrum 1800 MHz
  - Issue is separation of land base terrestrial networks from on-board usage
  - On-board base station:
    > geolocation”: switching off depending on ship position
    > in-door” only
Spectrum policy: EU research action

- **Community funding of R&D:**
  - collaborative R&D
  - networks of excellence
  - coordination and support action
  - Infrastructure building

- **7th Framework Programme: 2006-13, 32.4bn €**

- **IST programme (9.1bn €)**
  - 7 “challenges”
  - Future emerging technologies (FET)
## Spectrum policy: EU research action

### ICT R&D / spectrum policy:

<table>
<thead>
<tr>
<th>Industry/Tech. needs</th>
<th>Socio-economic goals</th>
<th>Future and Emerging Technologies (FET)</th>
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<tbody>
<tr>
<td>1. Network and service infrastructure</td>
<td>4. Digital libraries &amp; content (~10%)</td>
<td>~9%</td>
</tr>
<tr>
<td>2. Cognitive systems, interaction, robotics</td>
<td>5. ICT for health (~9%)</td>
<td>~8%</td>
</tr>
<tr>
<td>3. Components, systems, engineering</td>
<td>6. ICT for mobility &amp; sustainable growth (~8%)</td>
<td>~4%</td>
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<td>7. ICT for independent living and inclusion (~4%)</td>
<td>~9%</td>
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Spectrum policy: EU research action on cognitive radio

- **E²R**: End-to-end reconfigurable networks

- **E³ (“Ecube”)**: framing project for cognitive radio
  End-to-end efficiency cognitive wireless networks technologies

  - **Objective**: To transform current wireless system infrastructures into integrated, scaleable and efficient managed ‘cognitive system framework beyond 3G’ to introduce cognitive systems in the wireless world
  - **Tasks**: reference architectures (including mapping on LTE), reference techniques, identifying regulatory needs, contributing to standardisation IEEE (P9100.4, P100.6) and ETSI RRS, advising CEPT, national regulators, EC; input to ITU discussions
  - **Budget**: 2008-2009, 18.6 m€

Follow-up project under evaluation
Spectrum policy: EU research action on cognitive radio

• Projects on ISM model related issues
  • PHYDAS: cognitive radio and opportunistic access scenarios
  • ARAGORN: CR applied to “ISM band” model
  • FARIMIR: developing behavioural rules used by CR in the “ISM model”

• Projects focusing on “White Spaces” related issues
  • QOMOS: potential applications for white spaces, cognitive wireless access
  • COGEU: enabling technologies based allowing commons or trading usage model in white spaces
  • PHYDAS: opportunistic use of white spaces, “good neighbourhood” approach

• Projects looking into specific technological
  • SENDORA: CR via wireless sensor networks, nomadic broadband access
  • SACRA: spectrum and energy efficiency using CR in multi-band environment
  • SAPHYRE: spectrum / cost / energy efficiency using CR for resource sharing
  • QUASAR: modelling spectrum sharing opportunities and assessing benefits
Spectrum policy: EU research action on Ultra-wide Band

- PULSERS: Pervasive ultra-wideband low spectral energy radio systems

- EUWB: framing project for UWB technologies
  Coexisting short range radio by advanced ultra-wideband radio technology
  
  - Objectives:
    > explore the enormous economic potential of the ground-breaking Ultra-Wideband (UWB) radio technology
    > extend the UWB concept with advanced cognitive radio, multi-band/multimode networking, and multiple antenna system concepts
    > enable the introduction of advanced services and competitive applications using the radio spectrum in a sophisticated manner
  
  - Tasks: inter alia
    > WP2: Cognitive UWB radio and coexistence
    > WP8: applications (public transport, automotive environment, home environment)
    > contributing to standardisation IEEE and ETSI
    > advising CEPT, national regulators, EC; input to ITU discussions

- Budget: 2008-2011, 20.7 m€

- WALTER: reference activities on
  > specifying, testing, and improving interoperability of UWB
  > ensuring coexistence of UWB with other radio technologies
Standardisation

- **ETSI responsible**: SDR and CR related activities in
  - the Technical Committee **Reconfigurable Radio systems (RSS)**
- working groups:
  > system aspects: developing SRD/CR scenarios
  > radio equipment architecture: defining functional blocks for reconfigurable base stations and mobile devices
  > functional architecture and CPC: studying functions of reconfigurable networks and the cognitive pilot channel functions
  > public safety: certification of software modules used in reconfigurable systems, CR in security and defence systems
- link between research and standardisation via the E3 project
- focus on standards (no test beds or own simulations)
- two phases:
  > delivery of technical reports and ETSI Guides (currently ending)
  > normative work (starting)
- work on white spaces to be included, taking EU needs into account
Section 8: Conclusions
Conclusions

- Collective use of spectrum: potential for improved efficiency in spectrum use.
- Dynamic spectrum usage: a possibly significant change of paradigm in spectrum management including handling access rights.
- Innovation potential, attractive and diversified services for the citizen, increased competition, realising important policy objectives.
- Concurring trends: technology facilitates sharing, the scarcity of radio resources forces to be efficient, and new trends in spectrum usage.
- Simple forms of shared use already practised and are viable.
- New sophisticated approaches are tried out, but with so far unproven record of economic viability, many technical questions unsolved.
- All players are solicited to developing a stable ecosystem for collective use.
- Shared use will require an adaptation of regulation: usage right definition / ownership, interference models, and responsibilities / liability regarding spectrum usage.
- Regulators should become (pro)active to gradually offer an enabling regulatory environment.
- Research on technical is still necessary. Standardisation efforts will be key, and global cooperation is called for.
- White spaces in the broadcasting bands are likely to become the next test case.
Towards the New Era for Radio Usage including White Spaces
Tokyo, 1 March 2010

References

**RSPG CUS Report**: Aspects of a European Approach to ‘Collective Use of Spectrum’ (RSPG08-244, 11/2008)


Legal, economic and technical aspects of collective use of spectrum in the EU: Study by Mott McDonald et alt., 2006

Radio Interference regulatory models in the EU: Study by Eurostrategies et alt. 2007

Workshop on cognitive radio/regulation: proceedings of event 28/2/2020

**Directorate General for Information Society and Media**: central website

**Radio Spectrum policy**: dedicated DG INFSO policy webpage (legislative reference documents, activities, general information)

**Radio Spectrum Policy Group** (RSPG): official website (RSPG reference documents, activities etc.)

**CEPT / ECC**: central website (access points for CEPT / ECC documents)

**ETSI RRS Technical Committee**: dedicated webpage (terms of Reference and activities)