Trends in Spectrum Management

Workshop on Spectrum Management and Harmonized use of Spectrum Resource
Nadi, Fiji
28 – 30 November 2017

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AGENDA

- Radio Spectrum and its Value to Economy
- Economics of Granting access to Spectrum
- Technological trends in Spectrum Usage
- Spectrum Licensing trends
- Institutional Best practices in Spectrum Management
- Regional Challenges on SM
Radio Spectrum and its Value to Economy
Why the need for Efficient SM now?
Fixed BB Growth Globally and across regions of the world

Notes:
- The developed/developing country classifications are based on the UN M49, see: http://www.itu.int/en/ITU-D/Statistics/Pages/definitions/regions.aspx.html
- * Estimate
- Source: ITU World Telecommunication /ICT Indicators database
Why the need for Efficient SM now?
Mobile BB Growth Global and across regions of the world

Active mobile-broadband subscriptions per 100 inhabitants, 2007-2016

Notes:
- The developed/developing country classifications are based on the UN M49, see: [http://www.itu.int/en/ITU-D/Statistics/Pages/definitions/regions.aspx.html](http://www.itu.int/en/ITU-D/Statistics/Pages/definitions/regions.aspx.html)
- * Estimate
- Source: ITU World Telecommunication /ICT Indicators database
Income from Spectrum Management

- Fees collected:
  - License application (not refundable);
  - License issuing, renewing and amendment;
  - Periodically (on monthly/annual basis) from spectrum users proportional with the occupied bandwidth, service type, used frequency, covered location, service area, time duration and etc.;
  - Penalties imposed in effect of breaching of regulation;
  - Type approval fee;
  - Special technical assistance;
  - Auction;

- Spectrum management authority could earn much more money than its administrative needs if a suitable spectrum pricing regulation developed

- Roughly, spectrum fee should not be more than 3~5% of net revenue of licensee
Income from Spectrum Management: Russian Case study

Spectrum fees V/s frequency range

Source: Russian case study submitted to BDT study 1 Resolution 9: The experience of the Russian Federation in the field of spectrum fees
Spectrum Fee per MHz: Russian Case study

Source: Russian case study submitted to BDT study 1 Resolution 9: The experience of the Russian Federation in the field of spectrum fees
Source: Russian case study submitted to BDT study 1 Resolution 9: The experience of the Russian Federation in the field of spectrum fees
Traditional methods of granting access to Spectrum

- Apart from unlicensed (commons) spectrum bands, the spectrum regulator has traditionally assigned frequencies within geographical areas to users, often via granting them a licence, which has normally been for their exclusive use.

- Three general ways are predominant:
  - **FCFS**: Giving licence to the first applicant for it, if that is the only one (First come, first served)
    - PMR frequencies
  - **Beauty contests**: Asking applicants to make written requests for the licence, and allocating the licences to those making the most convincing case
    - Commercial mobile services in smaller market
  - **Reserving particular entity**: Specially for which there was excess demand at a zero or negligible price
  - Government spectrum use
Spectrum Auctions

• Practical use of this auctions started about 25 years ago, although the notion predates that considerably.

• In the early days, a small number of licences were auctioned:
  • in the same band,
  • their use confined to mobile services
  • Technology specific
  • Applicant could only be awarded one licence

• Over the years there have been 2 major developments:
  • Identical units of spectrum have been auctioned as individual lots, leaving it up to the firm to decide, within limits, how many to bid for
  • Auctions now often contain lots in several different bands, allowing firms to put together at one time a combination of holdings with different characteristics

Spectrum regulators choosing the auction route now have a wide choice of auction designs.
Recent Criticism and problems

- Revenue or BB growth
  - Arguments that state sees spectrum primarily as a resource to be sold to raise revenue, and restricts its availability for that end, rather than seeing spectrum as a means of extending the coverage and take up of mobile voice and broadband, and thus promoting economic growth and development.

Studies have shown that a 10% increase in mobile voice or broadband penetration increases a country’s national income by in excess of 1%. This benefit should take priority over increasing revenue from spectrum sales.

Difficulty?

How to incorporate Auction as spectrum assignment method while including objectives, such as extending network coverage and WITHOUT adding complexity that adds to the risk of failure?
# Grating Spectrum Access

<table>
<thead>
<tr>
<th>Cost Recovery</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Most straightforward to administer</td>
<td>• Often too low to instil discipline in ensuring spectrum efficiency</td>
</tr>
<tr>
<td></td>
<td>• For national interest/public service</td>
<td>• Tendency to maintain the same fees for years without review</td>
</tr>
<tr>
<td><strong>01</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spectrum Auction</td>
<td>• Transparency &amp; fairness</td>
<td>• Potential of overpricing; affecting operators’ profitability</td>
</tr>
<tr>
<td></td>
<td>• Outcome determined by market demand</td>
<td>• Often with a long licence duration</td>
</tr>
<tr>
<td></td>
<td>• For commercial services, highest economic value</td>
<td></td>
</tr>
<tr>
<td><strong>02</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administrative Incentive Pricing</td>
<td>• Encourage users to optimise spectrum; avoid hoarding</td>
<td>• Difficult in establishing the right level of pricing</td>
</tr>
<tr>
<td></td>
<td>• Reflect the value of spectrum and generate revenue for the government</td>
<td>• May result in spectrum being underutilised if the prices are too high</td>
</tr>
<tr>
<td><strong>03</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Deciding: *How much Spectrum to Auction?*

**International Influence**
- To some degree this is determined by international rules established by the ITU at World Radio Conferences;

**Availability**
- It also depends on whether any spectrum which is being re-assigned has been cleared of its previous licensees

**Supply may satisfy demand but priorities may be different**
- As noted, there has been a recent tendency to combine spectrum from several bands in a single award, to give bidders more choice over what to buy
- The regulator may be tempted to restrict the size of an award to create an *artificial shortage* and put the price up

  - **BUT consequences are that** Spectrum shortage will push up the price of and reduce the take-up of mobile communications services, and this risks slowing down the country’s growth rate

Temptation is short-sighted and should be resisted
Deciding: When to auction spectrum?

• Low access frequencies: *High demand*
  • Less choice and need a balanced approach
    • Ever increasing demand from commercial mobile sector
  • Decision of when depends on band clearance

• Higher frequencies: *Lower demand*
  • More choice on auction’s timing.
  • The choice is essentially whether it is better to hold the band in the regulator’s inventory OR to make it available to a licensee even if that licensee will not use it immediately

• Importance of Spectrum Trading
  • If the spectrum is tradable, so that a licence bought for one purpose can be sold for use in another purpose,
    • *Early release* may speed up innovation
      • depending on whether the regulator has sufficient resources to conduct non-urgent auctions.

Delaying an auction is as detrimental to a country as is withholding it permanently
Challenges with Auction

- Collusion of operators

- Too Few Bidders
  - In recent auctions for mobile spectrum, the number of bidders has been limited
    - Sometimes Regulator intentionally restricts new operators in market to avoid over heating/over competition.

- Regulator’s reaction to challenges
  - A good regulator would never welcome the problems created winner’s curse
  - Regulators design Auctions in way to ensure that collusion of bidders does not occur
    - By taking or publishing strenuous steps to find and punish such actions.
  - Reserve Price Dilemma
    - Too low a price, and the operators can retain excess profits; too high a price, and the spectrum will remain unused, probably for a long period
Telecom Revenues

Global telecommunication revenues declined by 4% between 2014 and 2015, falling back to USD 1.9 trillion.

Developing countries saw a compound annual growth rate in telecommunication revenue of 6.6% in the period 2007-2015, whereas developed countries experienced a contraction of -0.8% during the same period.

Developing countries are home to 83% of the global population but generate only 39% of the world’s telecommunication revenues.

Source: ITU.

Radio spectrum shall continue playing ever more vital role in provisioning of broad variety of radiocommunications services - public, private and governmental alike

Pressure on spectrum managers to find solutions to ensure unrestricted long term growth of services through allocation of new bands and finding innovative ways of more efficient utilisation of spectrum

TIME TO CRANK EFFICIENCY OF SPECTRUM USE, TIME TO SHARE ITS BENEFITS EVEN MORE ..
Technological Trends in spectrum usage
Why the need for Efficient SM now?

4th wave of growth in telecom sector

Current wave is defined by its complexity
Why the need for Efficient SM now?

Demand of Content – Internet Traffic Explosion

37% of Internet traffic during prime time is online video

Video
~ 70% of internet traffic by 2014

Smartphones
2.5 billion devices by 2015
32x increase per km²

Mobile Internet
~ 70% of mobile traffic by 2014

Machine-to-Machine
3x growth in the next five years

Mobile broadband networks are at the heart of this trend ...

Source: ITU Report M. 2290-0 and Alcatel Lucent
Why the need for Efficient SM now?

Traffic Explosion - beyond 2020

Estimation of Mobile traffic by different service types: Globally

Source: ITU Report M. 2370-0
Why the need for Efficient SM now?

Drivers for traffic increase

Accelerated Deployment of new IMT technologies

Growth of M2M applications

Enhanced Screen Resolution

Cloud Computing

FBB Replacement by MBB

Growth in Audio/visual and media streaming and unicast media consumption

Proliferation of ambient screens

Subscriber behaviour

Evolution in usage/traffic characteristics

Deployment timescale

Shifting demography: Urbanisation trends

Source: ITU Report M. 2370-0
Why the need for Efficient SM now?

Estimation of global mobile subscriptions with different categories

Beyond 2020

Source: ITU Report M. 2370-0
Technology Trends

Commercial Mobile Services

- General Trend of Timely availability and efficient use of spectrum
- All upcoming IMT/IMT Advanced technologies based around data
- Increasing requirements of Spectrum for access

Source: ITU-R Recommendation M.2083-0 (09/2015)
Technology Trends

Commercial Mobile Services

- **Pre-IMT**
  - 1990s – 64kbps

- **IMT2000**
  - 2000s – 2Mbps

- **IMT-Advanced**
  - NOW – 100Mbps – 450Mbps

- **IMT2020**
  - Beyond 2020 – Above 1Gbps
# Technology Trends

## Commercial Mobile Services - IoTs

<table>
<thead>
<tr>
<th>Standards</th>
<th>Short-range</th>
<th>Long-range Unlicensed</th>
<th>Long-range licenced</th>
</tr>
</thead>
<tbody>
<tr>
<td>IoT Access</td>
<td>Bluetooth, Wi-Fi</td>
<td>SIGFOX, LoRa, NB-IoT, LTE Cat-M1</td>
<td>LTE Cat-M1</td>
</tr>
<tr>
<td>Range</td>
<td>Up to 200 m</td>
<td>Up to 50km</td>
<td>Up to 50km</td>
</tr>
<tr>
<td>Spectrum Bands</td>
<td>ISM Bands (915MHz, 2.4GHz, 5.8GHz)</td>
<td>900MHz (868MHz in Europe and 902MHz in the US)</td>
<td>Mobile operator spectrum</td>
</tr>
<tr>
<td>Applications</td>
<td>Wearables, home automation, tolls</td>
<td>Sensing, smart grid, smart city, monitoring</td>
<td>Automotive, logistics transportation</td>
</tr>
</tbody>
</table>

**IoT Reference Model**

Technology Trend

Terrestrial Broadcast Services

- Trend of A to D conversion with cut off dates defined
  - DSA and TVWS
- Further planning of SFN
- Adoption of APT 700 MHz band plan (more band for Mobile Services)
- Usage of more spectrally efficient broadcasting technologies
- ITU portal on status of the Status of the transition to Digital Terrestrial Television Broadcasting
  
Technology Trend

Terrestrial Broadcast Services

- DSA and TVWS (SM Issues)
  - Cross Border Interference
    + The need to take into account cross-border coordination in accordance with the Radio Regulations;
  - Detailed Spectrum occupancy Requirements
    + The need for mature sensing technology, if applicable, to be able to measure accurately the spectrum occupancy;
  - Risk Assessment of long term investment in TVWS
    + The risk for investments in opportunistic uses, associated with the uncertainties on the medium and long term availability of spectrum, either as a result of changes in the spectrum requirements of higher priority users or as a result of a change in higher priority allocations;
  - Enforcement of License Conditions
    + The challenge of ensuring the compliance of the devices with national and international regulations and the enforcement of these regulations. These compliance and enforcement aspects will need to be addressed in a satisfactory way if such spectrum sharing technologies are to be implemented in the future;
    + The database related issues including complexity reliability and management if applicable;
  - Technical Challenges
    + The technical challenge of developing devices that are able to operate in any channel over a wide frequency range while having to avoid adjacent channel interference into higher priority services.

Source:
Technology Trend
Terrestrial Broadcast Services

- **International Regulations**
  
  + **RR 4.4** Administrations shall not assign ...any frequency in derogation of either the Table of Frequency Allocations ..., except on the condition that using such assignment shall not cause harmful interference to, and shall not claim protection from a station operating in accordance with ...these Regulations. Means usage is not stable (reliable) : if there are no free channels for TVWS device, it has to switch-off, stopping service to customers
  
  + **RR18.1** No transmitting station may be established or operated ... without a licence issued in ... conformity with the provisions of these Regulations by or on behalf of the government of the country to which the station is subject. All radios shall operate under a license (individual or general ) and follow established national rules

- **Some references of ITU Work on the TVWS and DSA** *(Dynamic Spectrum Access)*:

  + Final Report Resolution 9: Participation of countries, particularly developing countries, in spectrum management “Evolving spectrum management tools to support development needs”
  
  + Resolution ITU-R 58 “Studies on the implementation and use of cognitive radio systems”
  
  + Recommendation 76 (WRC-12) “Deployment and use of cognitive radio systems”
  
  + Question ITU-R 230-3/5 “Software defined radios”
  
  + Question ITU-R 241-2/5 “Cognitive radio systems in the mobile service”
  
  + Question ITU-R 235/1 “Spectrum monitoring evolution”
  
  + Report ITU-R SM.2152 “Definitions of Software Defined Radio (SDR) and Cognitive Radio System (CRS)”
  
  + Report ITU-R M.2225 “Introduction to CRS in LMS”
  
  + Report ITU-R M.2242 “CRS specific for IMT systems”
  
  + PDN Report ITU-R [LMS.CRS2]” CRS in land mobile service
  
  
Technology Trend
Land Mobile Services

- Trend of A to D conversion with simple data services like SMS
- More spectrum efficient equipment
  - Digital land mobile equipment operates with 12.5 kHz (or 6.25 kHz) as compared with 25 kHz for analogue equipment
- Spectrum demand from some services fading
  - Paging replaced by SMS and Walkie Talkie by Smartphones that can mimic the same service
- Spectrum demand from new consumer oriented mobile systems
  - Family Radio Systems and General Mobile Radio Systems (GMRS) (462/467 MHz)
- Critical role in Emergency and Public safety systems
  - Public Protection and Disaster Relief (PPDR) systems require more spectrum to support mobile video (WRC agenda item 1.3 – BB in UHF)
**Technology Trend**

**Short Range Devices**

- SRDs will continue to be in demand as connected home and Internet of things (IoT) becomes a reality.

- New Equipment making use of unlicensed spectrum to have applications including
  - **WLAN** - Three blocks of spectrum in the 5GHz range for radio LAN – 5150 – 5350 MHz, 5470 – 5725 MHz and 5725 – 5875 MHz already identified. Manufacturers are developing wireless access in higher frequency range (57 – 66 GHz) to support multiple Gbps data rate (European standard EN 302 567)
  - **RFID**
  - **NFC**
  - **UWB based applications**
  - **Radiolocation** - WRC 2015 agenda item 1.18 will consider the allocation to the radiolocation service for automotive applications in the 77.5 – 78.0 GHz frequency band

- Manufacturers working through the ITU and other standardisation bodies to harmonise the frequency ranges and the technical standards.

- Administration working to have Mutual Recognition Agreement (MRA) in order to ease the Type approval process and generate economies of scale
Spectrum Licensing: Trends

Models of spectrum management:

- Command and control model
  - Primary market
- Market-oriented model
  - Secondary market
  - Flexibility
- Common Use model
  - Full Liberalization

Source: Telecom Advisory Services, LLC
<table>
<thead>
<tr>
<th>Model</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| **Unlicensed spectrum (common-use bands)**                           | • The use of the bands is free and is regulated solely on the basis of technical restrictions and type-approval of equipment in order to limit interference to other services  
• Currently, the application of common bands is becoming more widespread in many industrialized countries (United States, United Kingdom, Canada) |
| **Combination of spectrum from various licensed operators**          | • This sharing model assigns given frequency bands for cooperative use in restricted geographic areas  
• The concept has been developed by New Zealand in what it calls “licensed spectrum parks”                                                                                                                   |
| **Use of software defined radio (SDR) and cognitive radio system (CRS)** | • Software-defined radio systems allow the operational parameters of radio frequencies, including band selection, type of modulation and output power, to be set or changed by means of software  
• Cognitive radio systems allow transmitters and receivers to adapt dynamically and independently to operational parameters and protocols based on information taken from the operating and geographic environment |
| **Sharing of spectrum using small cells**                            | • When the primary licensee uses spectrum in remote areas, this spectrum can be reused by small cells in high-demand urban areas that are far away from the remote location  
• For example, the United States telecommunications regulator allows shared-spectrum use and the deployment of small cells in the 3.5 GHz band, where maritime radar is the primary user |
| **Combinations of wireless networks (e.g. Routing cellular traffic through Wi-Fi sites, off-load)** | • Combining Wi-Fi and cellular technologies that operate in different spectrum bands means that a large amount of the increase in wireless traffic can be accommodated  
• Analysts estimate that 40 per cent of wireless traffic (mainly Internet access) is routed via public and private Wi-Fi locations |

Source: Telecom Advisory Services, LLC
# National Spectrum regulation strategies

- Technology neutrality and Spectrum Licensing

<table>
<thead>
<tr>
<th>Attributes</th>
<th>ALs (Apparatus Licenses)</th>
<th>SLs (Spectrum Licenses)</th>
<th>CLs (Class Licenses)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regime focus</strong></td>
<td>Device-centric</td>
<td>Space-centric</td>
<td>Tech-centric</td>
</tr>
<tr>
<td><strong>Efficiency objective</strong></td>
<td>productive (use)</td>
<td>allocative</td>
<td>dynamic</td>
</tr>
<tr>
<td><strong>Exclusivity</strong></td>
<td>medium to high</td>
<td>very high</td>
<td>none</td>
</tr>
<tr>
<td><strong>Coordination rules</strong></td>
<td>administratively set</td>
<td>proprietary</td>
<td>self-governed</td>
</tr>
<tr>
<td><strong>Flexibility (tech-service)</strong></td>
<td>none to moderate</td>
<td>high</td>
<td>variable</td>
</tr>
<tr>
<td><strong>Individually assigned</strong></td>
<td>Yes or No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Assignment by</strong></td>
<td>ad-pricing, auction</td>
<td>auction</td>
<td>not assigned</td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td>admin fee / market pr.</td>
<td>market pricing</td>
<td>free</td>
</tr>
<tr>
<td><strong>Tenure and Term</strong></td>
<td>up to 5 years/renew.</td>
<td>15 years / renew.</td>
<td>Unlimited</td>
</tr>
<tr>
<td><strong>Interference protection</strong></td>
<td>provided</td>
<td>provided</td>
<td>not provided</td>
</tr>
<tr>
<td>** Tradable**</td>
<td>Moderate</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td><strong>Sub-division</strong></td>
<td>not allowed</td>
<td>allowed</td>
<td>not possible</td>
</tr>
<tr>
<td><strong>Coordination needed</strong></td>
<td>low</td>
<td>high</td>
<td>very low</td>
</tr>
<tr>
<td><strong>Service – tech neutrality</strong></td>
<td>usually none</td>
<td>high</td>
<td>high or low</td>
</tr>
</tbody>
</table>

**Example:** Australian Licensing System
Spectrum Licensing: Trends

Source: Telecom Advisory Services, LLC
Novel solutions that promote various forms and degrees of organised sharing of spectrum:

- Light-licensing
- Authorised Shared Access/Licensed Shared Access
- Pluralistic Licensing, etc.

Source: Adapted from US PCAST report
Institutional Best practices in SM
Increasing trend towards seeing ICT policy and regulation as integral part of overall national infrastructure provisioning platform

Source: ITU – Based on data form 158 countries
Setting up efficient SM organization:

- Achieving streamlined and efficient SM on both short-term and long-term basis
- Allocating spectrum in an economic and efficient manner, and by relying on market forces, economic incentives and technical innovations

Transparency of SM operations:

- Promoting transparent, non-discriminatory, economically efficient and effective SM policies, that provide regulatory certainty

Technological neutrality and flexible spectrum use:

- Promoting wireless innovation, by creating conditions for the development of new services, reducing investment risks and stimulating competition among different technologies, including facilitating entry into market of new competitors
Timely availability and efficient use of spectrum

- Facilitating timely introduction of new applications and technology, while protecting existing services from harmful interference; ensuring most efficient use of radio spectrum

International harmonization:

- Aligning domestic spectrum policies with international best practices, in order to achieve faster take-up of new bands and economies of scale

Affordable and fair spectrum access:

- Reducing financial barriers for new wireless entrants to the market and promoting development of wireless technologies, especially in less developed areas

- Ensuring that all wireless players have equitable and fair access to spectrum resources
### Granting Access to Spectrum

#### UK : Study Case

<table>
<thead>
<tr>
<th>SM method</th>
<th>% of spectrum allocated in the UK (source: Ofcom)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year 2000</td>
</tr>
<tr>
<td>Administrative</td>
<td>96 %</td>
</tr>
<tr>
<td>Market</td>
<td>0 %</td>
</tr>
<tr>
<td>Commons (Unlicensed Spectrum)</td>
<td>4 %</td>
</tr>
</tbody>
</table>

Market consultations and self-regulation as means of deciding the most economical way to utilise spectrum are gaining importance.
Spectrum Usage Efficiency: *Russian Case study*

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**Group of radio technologies**

- Advanced
- Digital
- Administration
- Analog
- Outdated

**size of spectrum fees and group of technology**

**Source:** Russian case study submitted to BDT study 1 Resolution 9: The experience of the Russian Federation in the field of spectrum fees
Visibility of Spectrum availability

- Important for operators to business strategy based on future resource availability

- Recommended to develop and publish a Master-plan on Spectrum Management
  - Such strategy document needs to be reviewed (which doesn’t mean modification) regularly (say annually or biannually)
Monitoring, market-supervision and enforcement become increasingly integrated fields of operation.

Trend to make all monitoring stations (including the regional stations spread throughout the country) a generic hub for control and enforcement functions, whereas one or more teams of inspectors would carry out regular inspections of:

- Licensed radio stations: prior and at regular intervals during their operation
- Vendors of radio equipment in order to control whether they put on the market suitable (type approved) equipment
- Assessment of interference complaints

Concept and studies on “cloud” monitoring by dispersed nodes.

Airborne Radio Monitoring
Market self-regulation, especially for the highly congested bands used by a limited set of professional operators

Bi or Multi lateral Cross Border Agreements practice is now becoming most optimal approach to mitigate cross border Radio Frequency interference issues in order to:

- Ensure equal distribution, and
- Speed up the day-to-day frequency assignments in border areas
HCM Agreement is the official designation of the Agreement between 17 European Administrations namely:

Austria, Belgium, the Czech Republic, Germany, France, Hungary, the Netherlands, Croatia, Italy, Liechtenstein, Lithuania, Luxembourg, Poland, Romania, the Slovak Republic, Slovenia and Switzerland.

Deals with Coordination of frequencies between 29.7 MHz and 43.5 GHz for fixed service and land mobile service.
Regional Challenges on SM
The SMTP comprises of two levels Basic and Advanced. Each level includes a number of obligatory (OM) and elective (EM) modules which are the following:

**Basic Level (OM and EM):**

- **OM1**: “Legal Basis and Regulatory Framework of Spectrum Management”;
- **OM2**: “Spectrum Engineering Fundamentals”;
- **OM3**: “Wireless Telecommunications Technologies”;
- **EM1-1**: “Spectrum Monitoring”;
- **EM1-2**: “Enforcement and Type Approval of Equipment”;
- **EM1-3**: “SM for Satellite Systems”;
- **EM1-4**: “SM for HF Systems, Science, Maritime and Amateur Services”;
- **EM1-5**: “SM for Aeronautical and Radio Determination Services and Military Systems”;
- **EM1-6**: “Computer-aided Spectrum Management”;
- **OM4**: “Economic and Market Tools of Spectrum Management”;
- **OM5**: “Strategic Planning and Policies for Wireless Innovation”;
- **EM2-1 (Legal Specialization)**: “Advanced Spectrum Authorization Regimes”;
- **EM2-2 (Legal Specialization)**: “Socio-Economic Impact of Spectrum Regulation; Competition and Consumer Protection”;
- **EM2-3 (Technical Specialization)**: “Terrestrial TV Broadcasting Planning and Digital Transition”;
- **EM2-4 (Technical Specialization)**: “Opportunistic Spectrum Access and Cognitive Radio”.

**Advanced Level (EM):**

- **EM2-3 (Technical Specialization)**: “Terrestrial TV Broadcasting Planning and Digital Transition”;
- **EM2-4 (Technical Specialization)**: “Opportunistic Spectrum Access and Cognitive Radio”.

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**Sustainable Expertise development**

**02**

**Automation of Spectrum Invoicing and licensing system**

**01**
ITU Academy
Spectrum Management Training Programme – SMTP

brought to you by
Czech Technical University in Prague

2 semesters of blended learning
lectures – distance education
practical training and exams – 1 week per semester in Prague

Beginning on January 30, 2017

1st semester

- Module 01: "Legal Basis and Regulatory Framework of Spectrum Management"
- Module 02: "Spectrum Engineering Fundamentals"
- Module 03: "Wireless Telecommunication Technologies"
- Module 04: "Spectrum Monitoring"

2nd semester

- Module 05: "Economic and Market Tools of Spectrum Management"
- Module 06: "Strategic Planning and Policies for Wireless Innovation"
- Module 07: to be decided
- Module 08: to be decided

Graduates will be issued ITU certificate

Tuition fee (for 2 semesters):
- USD 1800 (regular – to be paid before November 30, 2016)
- USD 800 (early – to be paid before October 31, 2016)

Czech Technical University

SMTP at CTU
contact & registration

Dr. Janine Hrad
E-mail: smtp@foc.tukeb.fel.cvut.cz
Phone: +420 224 332 563

Summary

- SM remains a vibrant sphere of activities that makes an important constituent part of ICT industry functioning and innovation

- Regulate/Manage Spectrum like natural resource AND for long term benefits

- ITU remains ready to work with you
“Committed to connecting the WORLD”