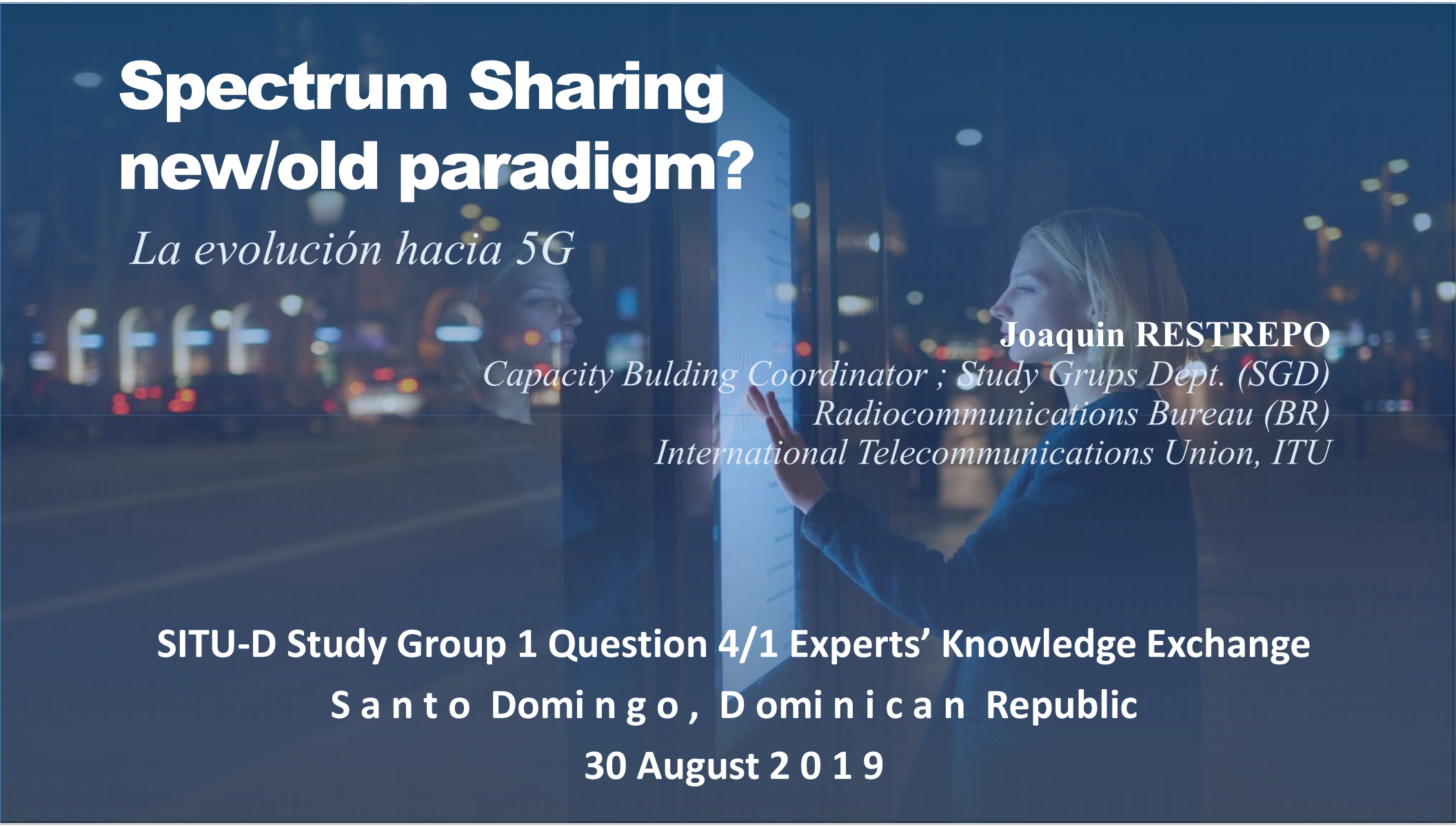

Spectrum Sharing new/old paradigm?

La evolución hacia 5G

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SITU-D Study Group 1 Question 4/1 Experts' Knowledge Exchange

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Spectrum Sharing Fundamentals

Goal: to optimize the spectrum use (and reuse) while preventing interference situations between concerned radio stations

Axes (Domains):

1. Frequency
2. Spatial
3. Time
4. Signal

Sharing principle: Radio stations shall operate using at least one different resource (separation) among the four axes

Spectrum Sharing Fundamentals

Spectrum sharing can be made trough:

- **Frequency Separation**: e..g, different carrier frequencies, hence used bandwidths do not overlap each other
- **Spatial Separation**: e..g, servicing different areas so they do not overlap each other
- **Time Separation**: transmitting at different time
- **Signal Separation**: different signal code, allowing to separate each other at the reception

Those separations can be

- Steady: regulatory framework
- Dynamic (changing in short time) technical standards and management

Spectrum Sharing Options (Rec. ITU-R SM.1132-2 (10/2001)**:**

Frequency Separation:

1. Channeling plans
2. Band segmentation
3. Frequency agile systems
4. Dynamic sharing:
    a. dynamic real-time frequency assignment
    b. Frequency division multiple access (FDMA)
    c. Control of emission
    d. spectrum characteristics
    e. Dynamic variable partitioning
    f. Frequency tolerance limitation
    g. Demand assignment multiple access (DAMA)
    h. Frequency diversity

Spectrum Sharing Options (Rec. ITU-R SM.1132-2 (10/2001)**:**

Spatial Separation:

1. Geographical shared allocations
2. Site separation
    a. Antenna system characteristics:
    b. adaptive antenna (smart antenna)
    c. antenna polarization discrimination
    d. antenna pattern discrimination
    e. space diversity
    f. antenna angle or pattern diversity
3. Space division multiple access (SDMA)
4. Physical barriers and site shielding

Spectrum Sharing Options (Rec. ITU-R SM.1132-2 (10/2001)**:**

Time Separation:

1. Duty cycle control
2. Dynamic real-time frequency assignment
3. Time division multiple access (TDMA)

Spectrum Sharing Options (Rec. ITU-R SM.1132-2 (10/2001)**:**

Signal Separation:

1. Signal coding and processing
2. Forward error correction (FEC)
3. Interference rejection
4. Code division multiple access (CDMA)
    a. Spread spectrum:
    b. direct sequence
    c. frequency hopping
    d. pulsed FM
5. Interference power/bandwidth adjustments:
    a. co-channel
    b. dynamic transmitter level control
    c. power flux density (pfd) limitation and spectral power flux density (spfd) limitation (energy dispersal)
6. Modulation complexity
7. Coded modulation
8. Adaptive signal processing
9. Antenna polarization

Spectrum Sharing Scenarios (Report ITU-R SM.2404-0 (06/2017):

Sharing can have different approaches:
- regulatory or a technology approach
- international or national levels

Sharing can be among:
- different radio communication services or applications
- different entities or type of users (e.g. governmental vs commercial use)
- different licensed users of the same/similar application (e.g. PMR services, Point to point links)
- protected primary users and licence-exempt users (e.g. radars and EESS vs 5 GHz RLANs);
- different licence-exempt users

Spectrum Sharing in IUT-R

ITU Radio Regulations, RR, is based upon the spectrum sharing principles, hence it contains:

- **Frequency separation**: as made on the Table of Frequency Allocations

- **Spatial separation**: as made on the different allotment Plans

In fact RR makes a combination of Frequency and Area spectrum sharing

In addition to it, ITU-R SGs have published plenty of standards (recommendations and reports) aiming to foster the spectrum sharing trough time and coding schemes

Spectrum Sharing at National Level

- Frequency/Spatial Spectrum Sharing at National Level (within a same band):
It requires a long term planning including a channeling Plan with their associated coverage areas (such a channel Plan can include time and code sharing)

- **Code sharing**: more related to a specific standard

- **Time sharing**:
  - **Technical**: more related to a specific standard in milisenconds and less
  - **Regulatory**: is more related to the license Term, shared in daily, monthly, yearly basis

Spectrum Sharing at National Level

The national regulatory matters about spectrum sharing is handled trough:

- **Allotment Plans:** that includes
  - **Frequency sharing**: channeling Plan
  - **Spatial sharing**: associated area(s) and/or Site(s) to each channel

- **License time terms:** may allow Time Sharing (long-time scale)

- **Standards**: it includes
  - **Time sharing** (technical, ultra short-time scale)
  - **Coding sharing**

  (in a technical neutrality scheme, these sharing axes are handled by the operator through the selected standard)

Spectrum Sharing Options

Shared Resource (Separation)	Regulatory (NRAs)	Technical (Standards)
Frequency	Allocation/ Allotment	Dynamic Frequency Sharing
Spatial	Allocation/ Allotment	Dinamic Antenna Pattern
Time	License Term	Dynamic Time Sharing
Signal		Signal Sharing

Secondary use is different than secondary service:

Secondary Service:

- Within NTFA
- NI/NP vis a vis Primary
- FIFS vs other secondary

Secondary user:

- Same service
- Other service: *NTFA shall include it*

Licensed Shared Access (LSA) (Report ITU-R SM.2404-0 (06/2017):

Spectrum sharing holds the potential for:

- improving the overall efficiency and effectiveness of spectrum use;
- improve the quality of providing telecommunication services;
- promoting economies of scale and encouraging investments;
- exploiting temporal and geographical dimensions by allowing users to access a particular piece of spectrum for a defined time period or in a defined area to increase the utilization of spectrum.

Licensed Shared Access (LSA) (Report ITU-R SM.2404-0 (06/2017):

Licensed Shared Access is

"A regulatory approach aiming to facilitate the introduction of radiocommunication systems operated by a limited number of licensees under an individual licensing regime in a frequency band already assigned or expected to be assigned to one or more incumbent users. Under the Licensed Shared Access (LSA) approach, the additional users are authorized to use the spectrum (or part of the spectrum) in accordance with sharing rules included in their rights of use of spectrum, thereby allowing all the authorized users, including incumbents, to provide a certain QoS"

Licensed Shared Access (LSA) (Report ITU-R SM.2404-0 (06/2017):

Key features of the LSA approach :

1. A “sharing framework”, for a given frequency band, will define the spectrum, with corresponding technical and operational conditions, that can be made available for alternative usage under LSA framework.
2. Establishing a “sharing framework” is under the responsibility of the RA and requires the involvement of all relevant stakeholders.
3. The NRA sets the “sharing framework” procedures for individual authorisations to LSA users and a set of “sharing rules” or “sharing conditions
4. The “sharing framework” will materialize the change, if any, in the spectrum rights of the incumbent(s) and define the spectrum, with corresponding technical and operational conditions, that can be made available for alternative usage under LSA.
5. LSA excludes concepts such as “opportunistic spectrum access”, “secondary use” or “secondary service” where the applicant has no protection from primary user.

ITU-R Relevant Publications

- **Radio Regulations:**
  - Table of Frequency Allocations (Art. 5 Vol. 1)
  - Band Plans (Appendices Vol. 2)

- **ITU-R Publications**:
- Recommendation ITU-R SM.1132-2 (10/2001): General principles and methods for sharing between radiocommunication services or between radio stations (prior versions: 1995-2000)

- Report ITU-R SM.2028-2 (06/2017): *Monte Carlo simulation methodology for the use in sharing and compatibility studies between different radio services or systems* prior versions: 200, 2002)
- Report ITU-R SM.2404-0 (06/2017): *Regulatory tools to support enhanced shared use of the spectrum*