6th 5G Global Event

Panel 3 – Spectrum Harmonization & Regulatory Issues

November 28th

Alberto Boaventura
Create a consistent vision for the use of radiofrequency spectrum (Spectrum Committee Report) for mobile services and 5G in the Brazilian market in order to support (and align with) future contributions to domestic (Anatel CBC), regional (Citel) and international (ITU.R TG5 / 1 and WRC) boards, through the recommendations made and taking as a background: (1) the technological requirements of the current standard; (2) spectrum requirements in the different bands (<1 GHz, 1-6 GHz, >6GHz) associated with the idiosyncrasies of the services, their demands and technical characteristics (e.g. propagation, interference, etc.); (3) the harmonization of use by observing spectrum usage trends in the global and regional environment, observing the current regulatory framework, coordination and coexistence between services, cleaning opportunities; (4) the optimization of its use through technologies of sharing, spectral efficiency and reuse.
7. 5G Overview:
   - Standardization, vision and premises of IMT 2020 / ITU-R M.2083 / NGMN / 3GPP, enabling technologies, case studies, services, business models, architecture, points of attention: radiofrequency, etc.

8. Overall Status of Bands:
   - Worldwide Status of Bands Worldwide;
   - Region Status of Bands (LATAM);
   - Brazilian Status of Band;

9. Opportunities & Pain Points:
   - Sub 1 GHz Bands (applications, occupation, candidate bands, TVWS, VHF, UHF, opportunities - eg range and width, sharing, services in use, threats - eg cleaning, interference and coordination, regional and global harmonization etc. enabling technologies for use: LSA, LAA, ASA, CR etc.);
   - MidBands 1 - 3 GHz: (applications, occupation, candidate bands, technology / service life cycle management and refarming, opportunities - eg range and width, sharing, services in use, threats - eg cleaning, coordination, regional and global harmonization etc., enabling technologies for use: LSA, LAA, ASA, CR etc.);
   - MidBands 3 - 6 GHz (applications, occupation, candidate bands, opportunities - eg CBRS, bandwidth and width, sharing, services in use, threats - eg cleaning, interference and coordination, regional and global harmonization etc.; enabling technologies for use: LSA, LAA, ASA, CR, SCN, HetNet etc.);
   - Above 6 GHz (applications, occupation, candidate bands, opportunities - eg bandwidth and width, sharing, services in use, threats - eg cleaning, interference and coordination, regional and global harmonization etc. - enabling technologies for use: LSA, ASA, CR, SCN, HetNet etc.);

10. Recommendations:
    - Sub 1 GHz (cleaning, managements, sharing, migration services, eg: LTE Broadcast vs. ISDB-T);
    - MidBands 1 - 3 GHz (sharing, cleaning: defragmentation, etc.);
    - MidBands 3 - 6 GHz;
    - Above 6 GHz
### Telecommunication Industry Scenarios: Evolution Waves

<table>
<thead>
<tr>
<th>Year</th>
<th>Internet</th>
<th>Mobile Internet</th>
<th>Internet of Things</th>
<th>Tactile Internet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>Enabled global communications; New form of entertainment; Communication cheaper;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>Voice traffic superior to data; Voice is the most important service; Non-Real-Time Applications</td>
<td>Growth of fixed broadband is 8% (CAGR) against 33% for mobile broadband; The number of MBB exceeds that of FBB in 2013; Data traffic already outperforms voice traffic. Data becomes more the most important service;</td>
<td>It will revolutionize all industrial segments through electronic integration and transaction, improving and optimizing its production processes; New innovation platform, inaugurating a new economic moment;</td>
<td>Experience not only audiovisual, but full immersion; They will help users (humanity) in complementing the perception of the world by bringing more information through sophisticated applications of Augmented Reality and Artificial Reality;</td>
</tr>
<tr>
<td>2010</td>
<td>Fixed broadband growth is 42% (CAGR) against 22% for mobile accesses; Fixed Broadband&gt; 64 kbps; Default ADSL.1 = 1-8 Mbps</td>
<td></td>
<td>In the next decade will be some tens of billions of connected objects Explosion of connected objects; Services with low latency and security have another relevance;</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>World wide web Dial Up xDSL Packet switching and TCP / IP</td>
<td>WAP EDGE, HSPA / HSPA + and LTE / LTE-A Android Video streaming and sharing Social networks Global Roaming</td>
<td>Access LPWA, SigFox, LoRA, LTE-M Computing in the Cloud; Cognitive computing; Big Data, Analytics, Machine Learning, AI Blockchain</td>
<td>Low latency systems: SDN / NFV; Fog Computing Quantum Computing Quantum Internet;</td>
</tr>
</tbody>
</table>

#### Transformation
- Enabled global communications;
- New form of entertainment;
- Communication cheaper;

#### Market
- Voice traffic superior to data;
- Voice is the most important service;
- Non-Real-Time Applications
- Fixed broadband growth is 42% (CAGR) against 22% for mobile accesses;
- Fixed Broadband> 64 kbps;
- Default ADSL.1 = 1-8 Mbps

#### Technology
- World wide web
- Dial Up
- xDSL
- Packet switching and TCP / IP
- WAP
- EDGE, HSPA / HSPA + and LTE / LTE-A
- Android
- Video streaming and sharing
- Social networks
- Global Roaming
- Access LPWA, SigFox, LoRA, LTE-M
- Computing in the Cloud;
- Cognitive computing;
- Big Data, Analytics, Machine Learning, AI
- Blockchain
- Low latency systems: SDN / NFV;
- Fog Computing
- Quantum Computing
- Quantum Internet;
## Network Evolution Challenges

### Requirements

<table>
<thead>
<tr>
<th>Technology</th>
<th>IMT 2000</th>
<th>IMT Advanced</th>
<th>IMT2020</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Service</strong></td>
<td>Voice+Multimedia</td>
<td>Voice+Internet</td>
<td>Broadband+Video</td>
</tr>
<tr>
<td><strong>Throughput per Sector</strong></td>
<td>1 Mbps</td>
<td>10 Mbps</td>
<td>150 Mbps</td>
</tr>
<tr>
<td><strong>Data Traffic</strong></td>
<td>&lt;66 PB/Month</td>
<td>240 PB/Month</td>
<td>5300 PB/Month</td>
</tr>
<tr>
<td><strong>Connections</strong></td>
<td>Accesses = 500 millions</td>
<td>Access = 1 billion</td>
<td>Accesses = 5 billions</td>
</tr>
<tr>
<td><strong>Carrier</strong></td>
<td>5 MHz</td>
<td>10 MHz</td>
<td>20 MHz</td>
</tr>
<tr>
<td><strong>IMT Spectrum</strong></td>
<td>WARC92 e WRC00 = 749 MHz</td>
<td>WRC07=+428 MHz</td>
<td>WRC15= + 709 MHz</td>
</tr>
<tr>
<td><strong>Site Density</strong></td>
<td>1 site/km²</td>
<td>5 sites/km²</td>
<td>50 sites/km²</td>
</tr>
<tr>
<td><strong>Backhaul Capability</strong></td>
<td>2 Mbps</td>
<td>20 Mbps</td>
<td>BH: 200 Mbps</td>
</tr>
<tr>
<td><strong>Latency</strong></td>
<td>500 ms</td>
<td>100 ms</td>
<td>10 ms</td>
</tr>
</tbody>
</table>
5G will represent the convergence of networks with different service requirements, which are better supported using specific spectrum range.

ITU-R M.2290 Report has updated the spectrum forecast for the year 2020, which results in a needed between 1340 and 1960 MHz (in Brazil 1129 MHz to 1676 MHz), depending on the market environment.

### Bands and Requirements

<table>
<thead>
<tr>
<th>Below 1 GHz</th>
<th>1 to 3 GHz</th>
<th>3 to 6 GHz</th>
<th>Above 24 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>N x 20 MHz (Total ~ 0.3 GHz)</td>
<td>N x 100 MHz (Total ~ 3 GHz)</td>
<td>1-2 GHz (Total ~ 30 GHz)</td>
<td></td>
</tr>
</tbody>
</table>

#### Spectrum Dilemma

- **Coverage**
- **Higher Connectivity**
- **Reliability**
- **massive Machine Type Communication**

#### System Capacity

\[
CAP = \#CS \times BW \times EF
\]

CS2 < CS1 \(\Rightarrow\) BW2 > BW2

Less Cell Sites need more bandwidth for the same system capacity.
Today there are no new bands below 1GHz for the 5G. Other UHF sub-bands were identified in Regions 2 and 3, but not globally harmonized (Region 1). Thus, they are being considered (470-698 MHz) for discussion in WRC23.

Although the 450 MHz band is identified for IMT since WRC07, it was the first proposal made to 3GPP on 2012 WI R4-124497 on 3GPP RAN #64.

There exists a lack of bandwidth with 5+5 MHz, insufficient to promote a fair completion with 2 or more players.

Currently it has initial usage after TVA switchoff in LTE networks.

It has high potential for 5G in mid and long term

Although it has already been identified in other regions, including part of the 700 MHz in Brazil, only after WRC12 has it become a global band for mobile use, with allocation and identification for IMT in Region 1.

There are no formal discussion about second wave of digital dividend in Brazil.

The range between 470-698 MHz was identified by regions 2 and 3, but not globally harmonized (Region 1). Considered for discussion in WRC23.

Inherited from trunking iDEN system, it has a potential of 15+15 MHz to be used for Mobile Broadband.

Currently is used for 2G, 3G and 4G technologies by operators that have license to use.

In total is 25 MHz with high potential to be refarmed to 5G.

Currently, based on Res 454/2006, there is a limitation to use 2.5+2.5 MHz per operator and in total there has been designated 10+10 MHz.

Potentially, it can double after cleanup and redistribution of existing services.
Midbands between 1 GHz and 3 GHz

These ranges of spectrum are fully used to previous mobile network systems: 2G, 3G and 4G. There are a few opportunities such as L Band and 2300 MHz.

This band has seen increasing interest from regulators following its identification for IMT in 2015. In the European Union, 1452-1492 MHz was opened for downlink use in 2015. The common sense is to use SDL for the full L-band i.e., 1427-1518 MHz.

These bands are currently used for 2G and 3G, and they are being reformed to 4G. They must be candidate to future 5G deployment and complement the existing assigned bands.

Band S is currently used in several initiative for ATG (Air To Ground). For instance Band 65 was recently created to enable ATG systems in Region 1.

Band 23, indicated below, is designated in the US for ATC (Ancillary Terrestrial Component) services complementary to the MSS.

This band has currently used as complementary Midband in recent auctions, such as Ofcom.

However 2300 MHz has expressive 4G penetration due China operators and as shared spectrum in EU using LSA.

In Brazil, it will complement 3500 MHz band in next year auction.

It has been used as preferable 4G (LTE) band around the world and specially Region 1 and in Brazil.

It has huge amount of traffic and it will be a candidate for 5G spectrum refarming.

Used for air control and military radars. It has not been widely supported for mobile broadband applications.
Midbands between 3 GHz and 6 GHz

C Band (3500 MHz) is being naturally harmonized around world as preferable Midband to 5G. Today there exists more than 35 trials and deployments in course accordingly to GSA.

This range has been Identified in the 3 Regions, but very limited in only a few countries of the regions; Japan and China are planning to used as band to 5G.

Unlicensed spectrum plentiful below 6 GHz - around 800 MHz;

Unlicensed spectrum is available and harmonized globally;

<6 GHz is preferable due to Path Loss;

The 5 GHz is free when compared to 2.4 GHz, dirty with most Wi-Fi and Bluetooth deployments;
**Agenda Item 1.13:** “To consider identification of frequency bands for the future development of IMT, including possible additional allocations to the mobile service on a primary basis, in accordance with Resolution 238 (WRC-15)”

### Bands Above 24 GHz

#### 26 GHz (24.25-27.5 GHz):
- Supported by the EU and China, it is an alternative to 28 GHz (27.5-29.5 GHz) partially allocated recently to the Ka band for satellite (Res 676/2017).

#### 32 GHz (31.8-33.4 GHz):
- Part of the Ka band in use for satellite, is under study for mobile terrestrial applications in WRC19.

#### 40 GHz (37-40.5 GHz):
- 40-5-42.5 GHz has no primary mobile allocation in Europe, although it is at least secondary in Region 1, China, South Korea, Japan and the USA.

#### 50 GHz (45.5-50.2 GHz):
- Used in radio navigation and other applications.

#### 70 GHz (50.4-52.6 GHz):
- Used in radio navigation and other applications.

#### 80 GHz (66-86 GHz):
- Allocated by ITU for use in fixed satellite (FSS) applications, but there are point-to-point radio solutions.

#### 66-76 GHz:
- Until recently allocated to satellite services, these are relatively new bands suitable for backhaul (Band E), where low-cost equipment is reaching the market.

#### 66-71 GHz:
- Band is allocated for mobile in at least Europe, China, Japan, South Korea and USA.

**GSMA Recommendation**

- **Top Priority:** 37-40.5 / 40.5-43.5 GHz
- **Top Priority TUNING RANGE:**
- **Maybe interest:** 66-71 GHz Growing Interest Unlicensed/IMT
- **Growing Interest:** 71-76 / 81-86 GHz Backhaul Possible access
THANKS!
OBRIGADO!

Q&A

Alberto Boaventura
alberto@oi.net.br