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Optimized Planning for TV 3.0 Channels

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Abstract— Given the current scenario of limited radio spectrum availability, this article explores alternatives for a simultaneous rollout of TV 3.0 and the existing Digital TV system without disruption. The proposed methods include the shared use of existing channels and the activation of new channels in new frequency bands. Using ITU-R Recommendation BT.2033-2, we will calculate a characteristic field strength value in dBμV/m for the Service Contour for the worst-case reception scenario. This is a planning parameter that supports the inclusion of new channels in the Basic Plan managed by Anatel. Once this field value is obtained, we will simulate the Service Contour of a hypothetical TV 3.0 station using the ITU-R P.1546 and P.1812 standards.

Index Terms— Coverage, propagation, regulation, TVD planning, and TV 3.0.

I. INTRODUCTION

THE Brazilian Digital Terrestrial Television System (SBTVD) Forum conducted the studies required to select the candidate technologies for the new digital television standard, known as Second-Generation Digital TV or TV 3.0 (DTV+). This work was carried out in collaboration with several Brazilian universities, the National Telecommunications Agency (Anatel), and the Ministry of Communications (MCom).

In accordance with Article 6 of Presidential Decree n° 11484/2023, the Ministry of Communications established a working group tasked with coordinating the development of technical regulations for TV 3.0 [1]. This group includes the participation of Anatel, representatives of the broadcasting sector, and the SBTVD Forum.

Through this Decree, the Brazilian government established guidelines to direct the technical work, which are defined as premises in Articles 1 and 2, transcribed below:

"Art. 1 This Decree provides for the guidelines for the evolution of the Brazilian Digital Terrestrial Television System - SBTVD-T.

Art. 2 The next generation of SBTVD-T, called TV 3.0, will be equipped with the following characteristics:

I - audiovisual quality superior to that of the first generation of SBTVD-T;

II - fixed reception, with external and internal antenna, and mobile;

III - integration between content transmitted by the broadcasting service and by the internet;

IV - application-based user interface;

V - segmentation of content according to the geographic location of the viewers;

VI - personalization of content according to the preferences of the viewers;

VII – optimized use of the radio frequency spectrum intended for the broadcasting service of sounds and images and ancillary services; and

VIII – new ways of accessing cultural, educational, artistic and informative content."

As stated in Item I, TV 3.0 must provide audio and video quality superior to the current Integrated Services Digital Broadcasting–Terrestrial (ISDB-Tb) system, with fixed reception supported by both indoor and outdoor antennas [1]. In ISDB-Tb outdoor antenna reception requires characteristic field strengths of approximately 43 dBμV/m for VHF and 51 dBμV/m for UHF [2], values that define the protected contour of the existing Brazilian Digital TV system.

On the other hand, TV 3.0 is expected to support mobile reception with performance comparable to the current technology [1]; in ISDB-Tb mobile reception is provided through the one-seg standard [3].

Another provision of the Decree emphasizes that broadcast and broadband must be integrated, ensuring compatibility so that both platforms deliver similar programming. A comparable concern exists in the United States regarding the coexistence of ATSC 3.0 and ATSC 1.0 (the first generation of Digital TV in USA). During this transition period, if broadcasters transmit substantially similar primary programming across both systems, they may hold multiple licenses on a shared host station. Otherwise, only a single license may be granted, as established in FCC 21-116 [4].

In the physical layer tests, several configurations were considered, among others a more robust configuration, with the lowest signal-to-noise ratio, with rates of at least 30 Mbps in a single layer within a 6 MHz bandwidth channel, 2X2 Multiple-Input Multiple Output (MIMO), with orthogonal, vertical and horizontal polarizations, 16K FFT and guard interval greater than 100 μs. Being enough to carry an 8K HDR program or two of 4K HDR or up to three different 1080P HDR programming, quality superior to the maximum quality supported by the current ISDB-Tb system [5].

The use of 2X2 MIMO antennas and the use of a single layer reduce the Carrier-to-Noise ratio (C/N) facilitating the achievement of the desired capacity, thus allowing a lower field value for fixed indoor reception [5].

This configuration will serve as the basis for calculating

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the minimum field strength required for both indoor and outdoor reception, which will be presented in Section IV. According to Article 2, Item II of Presidential Decree No. 11.484/2023 [1], one of the premises of TV 3.0 is fixed reception using both external and internal antennas. Therefore, for calculation purposes, indoor reception must be considered in various building types—such as houses, apartment complexes, and offices—taking into account signal attenuation caused by structural penetration to ensure reliable reception with indoor antennas.

The Forum physical layer tests aimed at two objectives, first to compare the candidate technologies among those that had the lowest C/N value for a given capacity, that is, a certain transmission rate; and another would be to measure the C/N required to recommend Anatel for spectrum planning purposes, that is, to calculate the values derived from C/N such as the values of the minimum field strength, the cochannel and adjacent channel protection ratio that are necessary to make the national and locality spectral occupation planning in order to protect these channels from possible interference [5].

The C/N is very important, as it will impose practical requirements for area coverage and interference limitations between TV 3.0 channels, and ISDB-Tb and TV 3.0 channels. For instance, a given C/N would enable frequency reuse-1, thus allowing for geographic segmentation and the delivery of regionalized content within a Single-Frequency Network (SFN) area.

When the carrier-to-noise ratio is insufficient for reuse-1 operation ($C/N \leq 0$), georeferenced content can still be delivered to viewers through IP-based geolocation. Alternatively, the unique identification of each transmitter may be employed, enabling more accurate and reliable polygonal geolocation than IP-based methods.

A third possibility is to use multiple layers (PLP's) with different requirements for C/N values, a more robust layer with a more general, non-georeferenced content or programming and a less robust one that would carry a different georeferenced content between transmitters, this happens when a receiver is close enough to a transmitter to have a sufficient protection ratio.

Tests with single-layer or two-layer reuse-1 resulted in a low bit rate of a maximum of 2.6 Mbps (indoor reception), insufficient rate for a video resolution higher than the current television standard, reuse would only be considered viable if it was possible to carry at least 1080p@59.94fps HDR programming that is a higher quality than the maximum possible in the current Digital TV system [5].

II. INTERNATIONAL CONTEXT

International experiences with the deployment of ATSC 3.0 provide relevant insights for the Brazilian transition to TV 3.0. In South Korea, the primary objective of implementation was to ensure that, by 2027, all broadcast content would be delivered in Ultra High Definition (UHD). Currently, UHD services are available to approximately 80% of the population. A key enabler of this transition was the allocation of additional spectrum, allowing each broadcaster to operate a second channel dedicated to ATSC 3.0 transmissions. This simulcast strategy facilitated a smooth migration process by maintaining service continuity while introducing the new technology [6]. Nevertheless, it is important to note that only a limited portion of the South Korean population consumes television via traditional broadcasting, which reduces the overall impact of spectrum-based strategies.

In the United States, migration to ATSC 3.0 is voluntary, with broadcasters free to decide whether to adopt the new standard. The main goals pursued include enhanced video and audio quality, improved accessibility, mobile interactivity, and the creation of new business models [4], [8]. To ensure service continuity during the coexistence of ATSC 1.0 and ATSC 3.0, the Federal Communications Commission (FCC) authorized channel sharing. Under this model, a 6 MHz physical channel can host multiple audiovisual streams from different broadcasters, enabling both ATSC 1.0 and ATSC 3.0 services to operate simultaneously. This approach preserves approximately 95% of the coverage of ATSC 1.0 services, although it postpones the full realization of ATSC 3.0's potential in terms of audiovisual quality, datacasting, and mobile services [4]. Typically, only one "lighthouse" transmitter is deployed per market, with no new spectrum allocated, relying instead on shared infrastructure.

In Jamaica, ATSC 3.0 has also been introduced, with at least one transmitter in operation. However, adoption remains limited due to the low penetration of ATSC 3.0-compatible receivers among the population, highlighting the importance of receiver availability and affordability in successful technology transitions [9].

III. SPECTRUM FOR TV 3.0

A. Occupation of Channels in Brazil

Considering the findings in [10], in which the results are shown in Figure 1, we can say that about 84.97% of Brazilian municipalities have some availability of channels for the implementation of TV 3.0, more than 31 channels in band 1 (green), ranging from 17 to 31 in band 2 (yellow), and in band 3 (red) availability of 17 channels or less, per municipality.

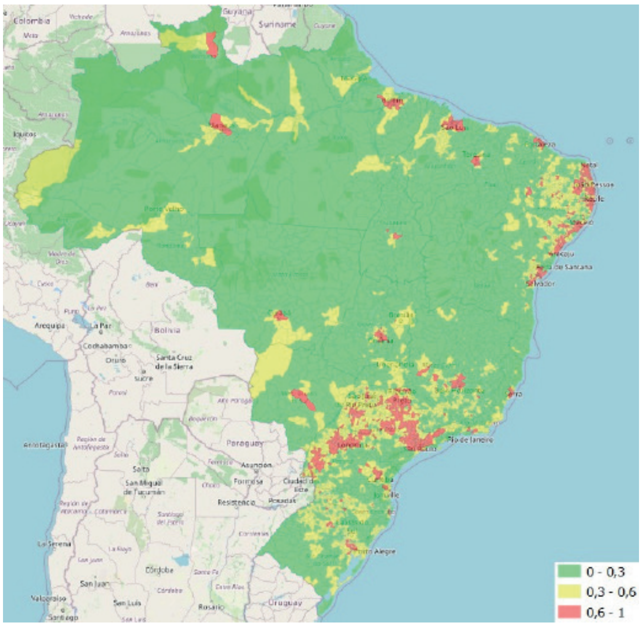

Figure 1 - TVD Spectrum Occupancy in Brazil

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It is worth remembering that the study in reference [10] only simulated the availability considering the interferences caused by cochannel interferences, not considering the interferences caused by adjacent channels. With this gap, it is expected that the actual availability of the channels will be lower than that calculated in the study.

Therefore, it is expected that in metropolitan regions the availability of channels will be scarce, in such a way that in these regions where there is a shortage of spectrum we should use some techniques to enable the continuity of services simultaneously (simulcasting) channel sharing can be used, among other alternatives, that is, a physical channel (a broadcasting station) should be shared between different entities with different audiovisual programming (different generators) with the purpose of "opening" spectrum for the installation of new channels with TV 3.0 technology

Another possibility would be the use of a new band spectrum, which Anatel is working on, but to use it it will be necessary to relocate actual users [11]. In this case, we can install TV 3.0 channels without discontinuity of ISDB-Tb services for users, to maintain the simultaneity of both technologies.

There is the on/off technique, that is, the stations are turned off in the 2.0 technology and activated in the new one. However, this technique would cause the discontinuity of services at the initial moment of transition between technologies for users, in which they would not have the most available service in the old technology, having to be "forced" to suddenly acquire a new television with the new technology to have access to programming. In this case, he would have to spend resources to acquire the new equipment.

B. National Channels

Considering that one of the alternatives would be the availability of new spectrum bands to enable the implementation of TV 3.0 technology smoothly without discontinuity of service for the ISDB-Tb user, it is one of the premises of all the actors involved, whether they are the Broadcasting Associations, MCom, or Anatel. These channels, herein referred to as National Channels, will be established in new spectral bands specifically to facilitate the deployment of TV 3.0. They will be exclusively allocated to a particular entity and valid across the entire national territory.

With the advent of the publication of Ordinance No. 10,693/2023 [12], this regulation guarantees the primary and exclusive allocation of the high VHF (174-216 MHz) and UHF (470-608 MHz and 614-698 MHz) bands for the implementation and development of TV 3.0. In addition, it advocates the availability of additional bands to enable the implementation of TV 3.0 and is also concerned with promoting the international harmonization of frequency spectrums for sound and image broadcasting and retransmission services.

With this normative framework, the Anatel began planning studies on how to obtain new frequency bands to make the normative premise viable. Thus, the possibility of using the 216 to 400 MHz band for television transmission in 6 MHz channels was evaluated, as can be seen in Figure 2; the crosshatched band of Amateur radio (220 - 225 MHz), SLP (Private Limited Service) and SLMA (242.5 and 243.8 MHz) and STFC (Switched Fixed Telephone Service), Radioastronomy and SLMA (Limited Aeronautical Mobile Service) services (322 to 335.4 MHz) were considered not to be susceptible to alteration or relocation due to the aggregation of life protection services, public safety and have international harmonization in region 2, administrative region to which Brazil belongs in the ITU division, which is the region of the Americas, according to reference [11].

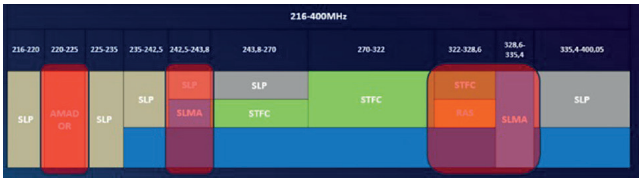

Figure 2 - Spectrum Distribution

With this, disregarding these hatched regions, and considering that a large portion of the services in this range will have their radiofrequency usage authorizations set to expire in 2025, along with the need to relocate some telecommunications services to enable spectrum reallocation and improve allocative efficiency, three frequency ranges will be opened for TV 3.0 allocation. These are:

- 231 to 237 MHz, which will accommodate one channel,
- 50 to 292 MHz, allowing for seven channels, and
- 345 to 363.5 MHz, providing space for three additional channels, as illustrated in Figure 3

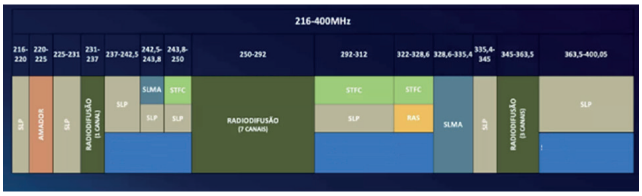

Figure 3 - National Channels Frequency Bands

There was a need to evaluate the guard bands to protect the contiguous services of these bands to avoid possible interference. Therefore, there are 11 new channels in new bands that can be used nationwide by the same entities.

On the other hand, there is the possibility of reserving the low VHF band (76 to 88 MHz) for national channels as well, totalling 20 channels (including the high VHF channels) under this national channel proposal. However, these frequencies present a technological challenge regarding the receiving antennas to be used, particularly in terms of efficiency (or gain) and their larger size compared to those used in the UHF bands.

According to the Anatel, the approval of the allocation of the 300 MHz band in the [11] for TV 3.0 was the result of debates held by the MCom, which brings together experts and representatives of the sector to define the technical parameters and guidelines for the adoption of the new technology in the country.

These three blocks were defined, exclusively for TV 3.0 channels [11]. Anatel warns that it will be necessary to

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refarm the band and clean the spectrum, with the release of stations that are currently occupied by private service operators (SLP) and fixed telephony (STFC), whose exploitation rights go beyond 2033. Therefore, [11] provides that these bands will no longer be licensed and will not have an extended authorization for use.

C. Channel Occupation Planning

In the context of the future implementation of TV 3.0 in Brazil, Anatel needs to reserve, plan and study channels, the respective channelling and their conditions of use of the frequency band with the new technical characteristics that technology TV 3.0 may require, such as the maximum power levels for each class and the protection ratios. It is in this context that we bring to the discussion a proposal on how to obtain the value of the electric field, a value that will be used to define the protected contour1 of the channels, and this definition is cited in [13].

The value of the characteristic field is of fundamental importance for the planning of new channels, as this value will define the coverage area of these channels, free of interference and with the necessary value so that reception can be made with an adequate C/N ratio to ensure the quality of reception and enable the new services to be made available in this new technology.

Therefore, we will propose the application of the method based on the recommendation ITU-R BT.2033-2 [7], in which the ITU proposes a planning criterion to obtain a characteristic field value for the Second-Generation Broadcasting System for the VHF and UHF bands, as shown in TABLE I of the sub-bands [14]:

TABLE I
VHF AND UHF BANDS

Band	Sub Band (MHz)	Channels	Obs.
VHF low	54 - 72	2 - 4	
	76 - 88	5 - 6	
VHF high	174 - 216	7 - 13	
	231 - 237	1 channel	new range
	250 - 292	7 channels	new range
UHF	345 - 363.5	3 channels	new range
	470 - 608	14 - 36	
	614 - 698	38 - 51	

IV. MINIMUN AND MEDIAM MINIMUN FIELD STRENGTH CALCULATION

Recommendation ITU-R BT.2033-2 [7] presents a series of equations for determining the characteristic field based on the sensitivity of the receptor, which will be presented next. The input parameters considered are the receiver noise figure (F) and the receiver's thermal noise, which will be obtained through the value of the actual channel width used in the Brazilian Standard of Second-Generation Digital TV, being 5.831 MHz, these values were obtained from Table 11 of the ABNT NBR 25609 standard [15]. Thus, the minimum and median field strength for configuration 1 of a TV 3.0 transmission whose characteristics are in TABLE II of the reference [15] will be calculated, that is, using a single 2x2 MIMO layer, 64-QAM modulation, bit rate of 32.32 Mbps and signal-to-noise ratio of 13.33 dB, among other parameters.

TABLE II
SINGLE LAYER MIMO2X2

Parameter	Value
Bandwidth	6 MHz
Useful Bandwidth	5.831 MHz
Modulation	64-QAM
Constellation	NUC
FEC	LDPC(8/15) 64800+BCH
iFFT Size	16K
GI Ratio	4_768 (111 µs)
Pilot Pattern	MP8_2
Pilot Encoding	Null Pilot (NP)
A. of OFDM Symbols	98
Team Interleaver	CTI 1024
Bit Rate (Mbps)	32.32
Theoretical C/N (dB)	13.33

We will now explain the procedure for calculating field strength values using the method recommended in reference [7]. For the purposes of this calculation, we will consider the geometric mean between the extreme frequencies of the UHF band from 470 to 698 MHz, resulting in 592 MHz as recommended by the [5]. And the calculations for the other ranges are summarized in TABLE A.1 of the Appendix.

While Brazil employs a 6 MHz television channel bandwidth, the operational value is 5.831 MHz. When this value is substituted into the kT_0B component of (1), the result is -136.3 dBW. Using the 6 dB receiver noise figure (F) specified in [15] and inserting these parameters into (1) produces a receiver input noise power (P_n) of 130.3 dBW.

$$P_n = F + 10\log(kT_0B) \tag{1}$$

$$= 6 - 136.3$$

$$= 130.3 \text{ dBW}$$

Using the computed P_n and the 13.33 dB carrier-to-noise ratio (C/N) specified as an input parameter in reference [15], we substitute these into (2) to determine the minimum receiver input power as -116.97 dBW.

$$P_{S\,min} = \frac{C}{N} + P_n \tag{2}$$

$$= 13.33 - 130.3$$

$$= -116.97 \text{ dBW}$$

Using this result from (2), we proceed to equation (3) to determine the minimum power density φ_{min} . This calculation requires two additional input parameters: the receiving antenna's effective aperture A_a and the feeder cable loss A_a connecting the antenna to the receiver input.

$$\varphi_{min} = P_{S\,min} - A_a + L_f \tag{3}$$

To proceed, calculate A_a through (4), and then return to (3). Then, for the antenna gain value G, given in dBd, we use table 4 of the reference [15] which records the value of -3.5 dBd for the UHF frequency range of 470-698 MHz, and for the wavelength λ we will use the geometric mean of the 592 MHz band in the value of 0.506, resulting in -17.9 dBm^2.

$$A_a = G + 10\,log(1.64\lambda^2/4\pi)$$
$$= -3.15 + 10\,log(1.64 \times 0.506^2/4\pi) \quad (4)$$
$$= -17.9\ dBm^2$$

Returning then to (3) and substituting the values found in (2) and (4) and considering that L_f it is also given by table 4 of reference [15] in the value of 1 dB, we have:

$$\varphi_{min} = P_{Smin} - A_a + L_f$$
$$= -116.97 - (-17.9) + 1$$
$$= -98.07 \text{ W/m2}$$

And finally, we can calculate the minimum field strength at the reception site with (5), using the result of (3) as input, substituting:

$$E_{mim} = \varphi_{min} + 145.8 \quad (5)$$
$$= 47.73\ dB\mu V/m$$

Adding two more parameters, we can calculate the median value of the minimum field strength we have (6) for the outdoor environment: being the noise generated by man P_{mmn} and the location correction factor C_1.

$$E_{med} = E_{min} + P_{mmn} + C_1 \quad (6)$$
$$= 47.73 + 1 + 2.86$$
$$= 51.59\ dB\mu V/m$$

This value is very close to the value that is used today in the protected contour for channel planning for ISDB-Tb, which is 51 $dB\mu V/m$ [2]. The calculated value was not smaller than the ISDB-Tb field due to the low gain of the MIMO receiving antenna expected to be used in this technology. On the other hand, this calculated value is for a fixed reception where the antenna is installed 10 meters from the ground. This configuration with an outdoor antenna at this height is already used today in the prediction and propagation standard used in the planning of ISDB-Tb channels in accordance with the ITU-R Recommendation P.1546-6 [17].

Then, it is possible to calculate the median value for indoor reception inside buildings, where we will have a field value that must "overcome the loss" of penetration in the building and the attenuation caused by the loss of height in relation to the value of 1.5 m of the reception antenna.

It will be observed that these values will cause a significant increase in the result from (6), raising it from 51 dBµV/m (rounded) to approximately 81 dBµV/m (rounded) – an increase of about 30 dB, as calculated by (7).

$$E_{med} = E_{min} + P_{mmn} + C_1 + L_h + L_b \quad (7)$$
$$= 47.73 + 1 + 4.23 + 16.91 + 11$$
$$= 80.87\ dB\mu V/m$$

The value of L_h is the loss of height caused by an indoor reception point that we consider 1.5 m above ground level in relation to the value of 10 m that is used as the standard outdoor value, this attenuation value is given through the reference [17] and the value of L_b is the penetration loss caused by the attenuation of the building in the electric field given through the reference [7].

TABLE A.1 was elaborated in the appendix, which summarizes the step-by-step calculation of the minimum and median field strength for an indoor and outdoor configuration. The calculation was also made considering the other frequency bands from 174 to 216 (VHF) and the new band from 231 to 363.5 recently identified for the National Channels.

V. COVERAGE SIMULATIONS

For the simulations, we considered the previously calculated values, rounded to form the proposed electric field value: 51 dBµV/m for TV 3.0 in an outdoor environment (which is the characteristic field value currently used to calculate channel coverage for ISDB-Tb) and 81 dBµV/m for indoor reception. To this end, coverage was simulated in the two prediction models, one using the ITU-R P.1546-6 Recommendation model [17], which is currently used to predict coverage in the Mosaic Computerized System (used by Anatel), and the other by ITU-R Recommendation P.1812-6 [18], which is more up-to-date and will be used in the future to replace 1546-6 [17].

The first recommendation calculates the point-to-area propagation and uses the Deygout-Assis method for point-to-point, while the second one computes the point-to-area propagation and uses detailed land cover and terrain profile data for point-to-point prediction.

A. Mosaic Simulation

It was simulated in the Mosaico software for an external reception antenna height of 10 meters, which is the standard height currently used in the current TV and which will be maintained for TV 3.0 for prediction purposes, and then a new simulation was made for a typical height of 1.5 m in the reception of portable and mobile devices. At this height, it can be extrapolated to calculate the indoor reception, just adding the loss of penetration in the building. In field tests, the value of the electric field can be measured at 1.5 m from the outdoor floor and then indoors and compared to obtain the value of the loss of penetration in the building, as recommended in [7].

Next, for didactic purposes, we will use hypothetical data in these simulations. Figure 4 through Figure 9 show the results of simulations performed with the maximum requirement specifications, all in Class C, featuring a maximum power of 0.08 W, an antenna height of 150 m, and a maximum distance to the protected contour of 18.1 km, according to reference [2]. Within this protected contour (circle in blue), let us consider the characteristic field value of 51 dBµV/m calculated earlier in section IV.

The protected contour is the service or coverage area of the station that will be protected from possible interference from other stations.

And an omnidirectional antenna was also used that radiates in all directions.

Figure 4 and Figure 5 were the results of the simulation in the ITU-R P.1546-6 standard [17] that uses a point-area method to calculate the electric field for a reception height of 10 m and 1.5 m respectively, where a reduction in the coverage area of about 8% was obtained.

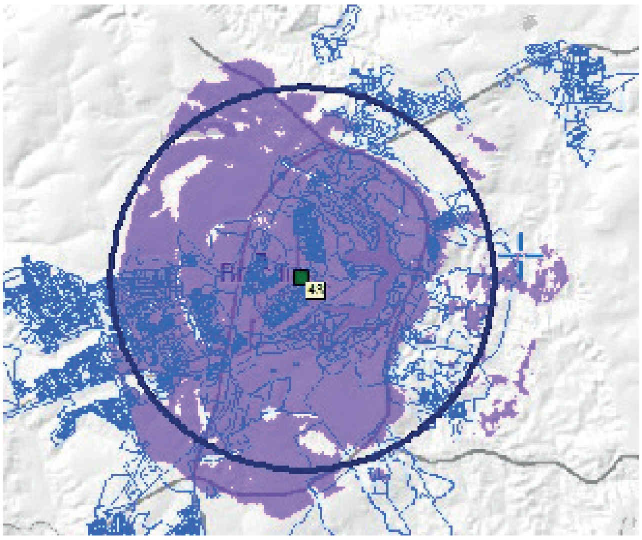

Figure 4 - Simulation in the ITU-R P.1546-6 standard - 10 m.
Urban residents covered: 93%
Urban area covered: 67%

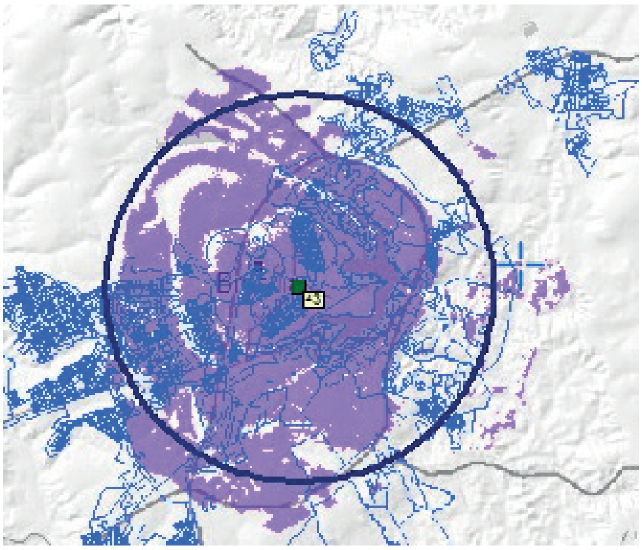

Figure 5 - Simulation in the ITU-R P.1546-6 standard - 1.5 m.
Urban residents covered: 87%
Urban area covered: 59%

Figure 6 and Figure 7 were simulated considering the ITU-R P.1812-6 Recommendation, which proposes a point-area method, but which also considers the calculation of diffraction and multipath effects, using digitized maps, with information on vegetation cover and clutter in the urban area, which would result in a more accurate prediction method than the ITU-R P Recommendation 1546-6.

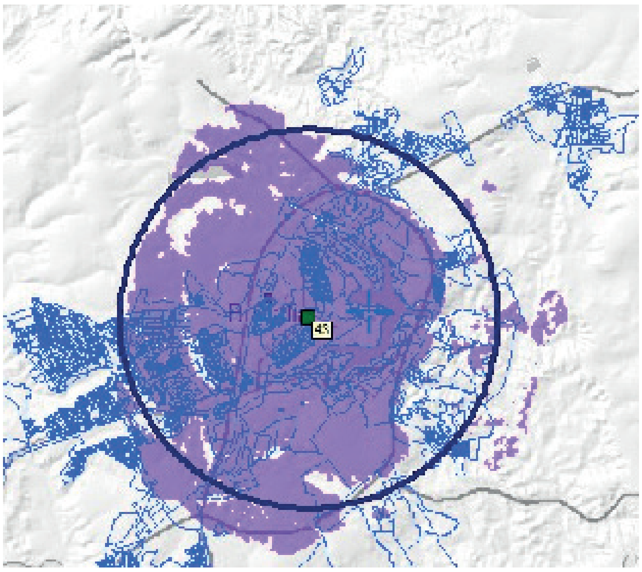

Figure 6 - Simulation in the ITU-R P.1812-6 standard - 10 m.
Urban residents covered: 91%
Urban area covered: 66%

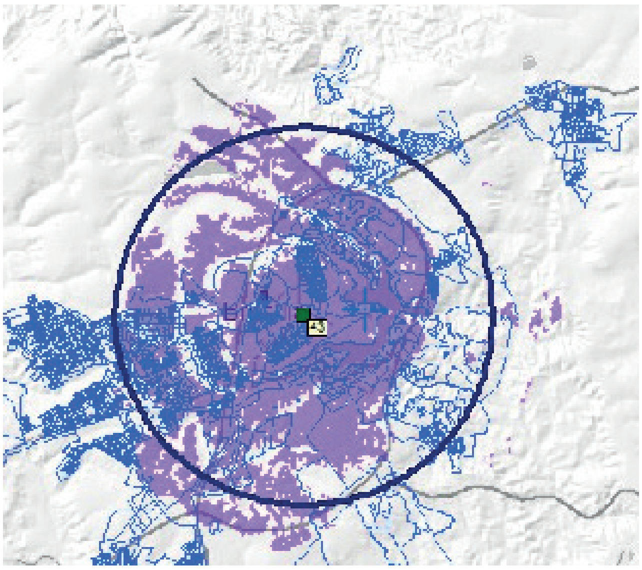

Figure 7 - Simulation in ITU-R P.1812-6 standard - 1.5 m.
Urban residents covered: 80%
Urban area covered: 53%

When comparing Figure 6 and Figure 7, the coverage area decreased by about 13% due to the difference in the height of the receiving antennas, being more pronounced in ITU-R Recommendation P.1812-6 than in ITU-R Recommendation P.1546-6.

In addition, a simulation was made with values of two overlapping coverage areas, resulting in spots 81 dBµV/m (red) and 51 dBµV/m (green), i.e., one with the field value for indoor reception and

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the other for outdoor reception, respectively, as we can see in Figure 8 and Figure 9 in both patterns.

For Figure 8, simulated in the 1546-6, the red spot resulted in a much smaller coverage area, about 22% of the outdoor coverage area. For Figure 9, simulated in the 1812-6, the area covered by the red spot was 9% of the outdoor reception area.

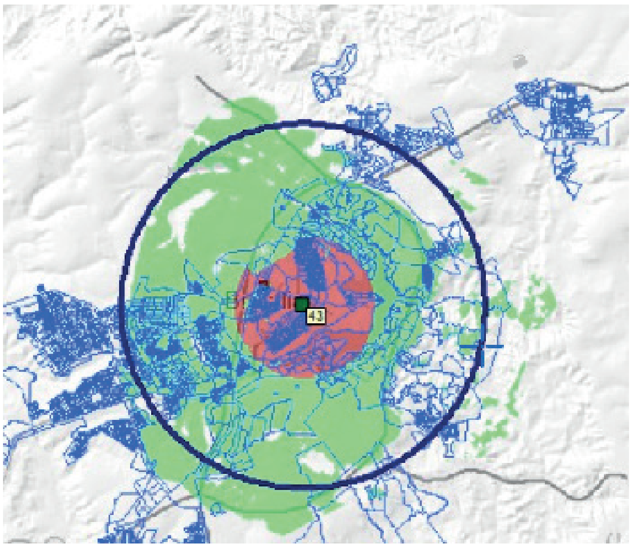

Figure 8 - Simulation in the ITU-R P.1546-6 standard -10 m.
With 81 dBμV/m (red) and 51 dBμV/m (green)

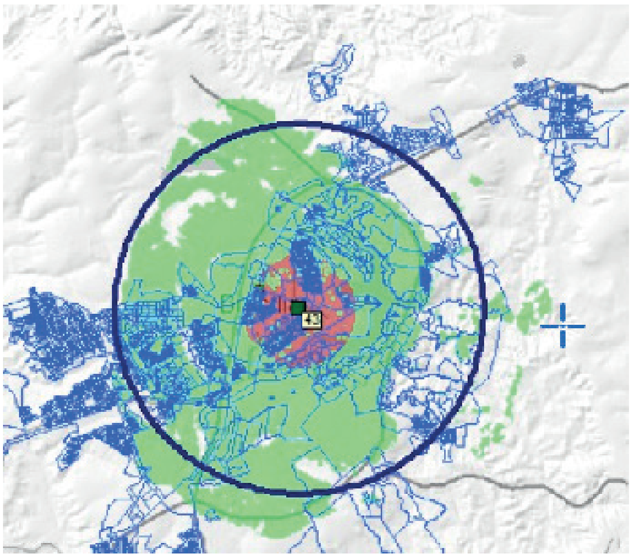

Figure 9 - Simulation in the ITU-R P.1812-6 standard -10 m.
With 81 dBμV/m (red) and 51 dBμV/m (green)

Thus, to enable indoor reception, considering only a single station at the same transmission point as shown in the Figure 8 and Figure 9, a power roughly a thousand times greater (30 dB) than the current class C ERP (effective radiated power) of 0.08 kW would be required. This results in a staggering 80 kW, which is the maximum power level currently permitted by regulations [2] for a digital television station.

In this case, even considering the energy and spectral efficiency gains that TV 3.0 technology brings in its ATSC 3.0 physical layer, it is not able to mitigate the impact of the increase in power to enable internal reception without compromising the broadcast sustainability.

As mitigation, we propose using smaller station, which we will refer to as complementary station, to be installed within the protected contour. These would operate at lower power levels while still achieving the target coverage area for the characteristic field strength of 81 dBμV/m.

We therefore suggest that subsequent work involve simulating complementary stations within the protected area to determine the quantity and power levels needed for viable indoor coverage

VI. CONCLUSIONS

In this work, we discuss that the implementation of the new Second Generation Digital Television technology will have several challenges such as spectrum availability and with a high increase in power levels due to the mandatory internal reception.

The lack of spectrum availability can be addressed both with the use of the National Channels and with the channels still available in the localities. But the promising method is channel sharing, where a channel with multiprogramming can allow the simultaneous transmission of up to four programs. Providing a smooth transition between digital technologies with channel sharing alternatives.

A proposal for the calculation of the electric field strength value for the protected contour of the stations was also presented, based on recommendation BT.2033-2, which was used for the coverage simulations of a hypothetical station. It is important to highlight that the field strength was calculated for a worst-case scenario. Under more optimistic conditions—such as a more sensitive receiver, more efficient antennas, and less severe height and penetration losses—the required field strength would be significantly lower than the value calculated in this study.

In the simulations presented by Figure 8 and Figure 9, we could visualize the areas or “spots” corresponding to the fields for outdoor and indoor reception. One prediction showed that the area for indoor reception was about 22% of the outdoor receiving area, resulting in an unthinkable increase of about a thousand times the power of a class C station for the same coverage.

In the current landscape, where energy efficiency is a universal concern, the Telecommunications Sector is also striving to make its systems, projects, and technologies more sustainable. One proposal to achieve this is the use of complementary stations designed for lower power transmission to enable indoor reception.

Since this topic is not fully addressed in this article, further studies on TV 3.0 coverage are required. We therefore propose the following for future work:

- Conducting simulations with complementary stations.
- Running simulations using real data from the TV 3.0 test station, including the implementation of two LDM layers.
- Performing field measurements for the TV 3.0 test

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station's coverage.

- Analyzing the predicted results against the easured data.

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APPENDIX

TABLE A.1- CALCULATIONS FOR INDOOR AND OUTDOOR RECEPTIONS

Factor	Symbol	174 to 216 MHz	231 to 363.5 MHz	470 to 698 MHz	Equations	References
Bandwidth (MHz)	B	5.831 MHz				ABNT NBR 25609:2025, Table 11
Boltzmann constant (J/K)	K	1.38×10^{-23}				ABNT NBR 25609:2025, Table 11
Absolute Temperature (k)	T_0	290				ABNT NBR 25609:2025, Table 11
Thermal Noise (dBw)	Nt	-136.3			$10\log(kT_0B)$	ABNT NBR 25609:2025, Table 11
Receiver Noise Figure (dB)	F	6				ABNT NBR 25609:2025, Table 11
C/N Threshold (dB)	C/N	13.33				ABNT NBR 25609:2025, Table 11
Center Frequency (MHz)	f_c	194	282	592		Geometric mean between the extreme frequencies of the range ABNT NBR 15608-1:218
Wavelength (m)	λ	1.55	1.064	0.51	$\lambda = C/f_c$	Calculated
Receiving Antenna Gain (dBd)	G_{Rx}	-6.15	-4.65	-3.15		ABNT NBR 25609:2025, Table 4
Effective antenna area (dBm^2)	A_a	-11.18	-12.95	-17.90	$A_a = G + 10\,log(1.64\lambda^2/4\pi)$	Calculated
Receiving antenna feeder loss (dB)	L_f	0.5	0.8	1		ABNT NBR 25609:2025, Table 4
Man-made noise (dB) Indoor/outdoor	P_{mmn}	8/2	4.5/1.0	1/0		REC. ITU-R BT2033-2 Table 31
Height Loss (dB)	L_h	12.25	13.78	16.91		Calculated Rec. ITU-R 1546-6
Penetration Loss (dB)	L_b	9	10	11		REC. ITU-R BT2033-2 -Tables 12 and 27
Standard deviation of penetration loss	σ_b	3	4.5	6		The standard deviation of penetration loss was obtained from the REC. ITU-R BT2033-2 -Tables 12 and 27, values 3 and 6dB, the value for 282MHz was interpolated (4.5dB)
Total standard deviation (dB) Indoor/outdoor	σ_t	6.26/5.5	7.1/5.5	8.14/5.5	$\sigma_t = \sqrt{\sigma_b^2 + \sigma_m^2}$ Being σ_m macro-scale standard deviation ($\sigma_m = 5.5\ dB$) and σ_b the standard deviation of penetration loss	The σ_m was obtained from the REC. ITU-R BT2033-2 -Table 34
Location correction factor (dB) Indoor/outdoor for 70% of the localities	C_l	3.26/2.86	3.69/2.86	4.23/2.86	$C_l = \mu \cdot \sigma_t$ μ is the distribution factor, being 0.52 for 70% of the localities, 1.64 for 95% and 2.33 for 99%	
Noise input power at receiver (dBW)	P_n	-130.3			$P_n = F + 10\log(kT_0B)$	
Minimum input power at receiver (dBW)	P_{Smin}	-116.97			$P_{Smin} = \frac{C}{N} + P_n$	
Minimum density at the reception location ($dB\ (W/m^2)$)	φ_{min}	-105.29	-103.22	-98.07	$\varphi_{min} = P_{Smin} - A_a + L_f$	
Minimum field strength at the receiving location ($dB\mu V/m$)	E_{min}	40.51	41.78	47.73	$E_{min} = \varphi_{min} + 145.8$	
Field Strength Equivalent to Minimum Median Outdoor ($dB\mu V/m$)	E_{medOut}	45.37	45.64	50.59	$E_{medOut} = E_{min} + P_{mmn} + C_l$	Reception with external antenna
Field strength equivalent to the minimum Median Indoor ($dB\mu V/m$)	E_{medInd}	**73.02**	**73.75**	**80.87**	$E_{medInd} = E_{min} + P_{mmn} + C_l + L_h + L_b$	Reception with internal antenna

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